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Producer Gas for Agricultural Purposes.

E. E. Freeth, School of Engineering, University of Western Australia.*

FOREWORD.

Following extensive experiments dealing with producer design and operation carried out at the School of Engineering of the University of Western Australia, the present work was undertaken to obtain first-hand knowledge of the operation of Tractors, fitted with producer gas plant, working under Field conditions.

The work described in this publication has been carried out by E. E. Freeth, B.E., under the direction of Dr. A. T. Bowden, Assoc. Professor of Mechanical Engineering, and forms part of the research activities undertaken by the University through the Commonwealth Research Grant to Universities administered by the Council for Scientific and Industrial Research.

Without the practical assistance of many interested parties the work, involving as it does the use of a large amount of equipment, could not possibly have been carried out, and we therefore take the opportunity of thanking those who did so much to make for the successful completion of the work. In particular we are greatly indebted to the following:

F. Mather, Esq., Kellerberrin, who placed his farm and equipment at the disposal of the University.

Westralian Farmers, Ltd., for making available a set of rubber tyres for the tractor, a special drawbar attachment, the use of a dynamometer and cylinder gauge, for supplying for test a model "U" "Allis Chalmers" Tractor equipped with "Pioneer" gas plant.

Powell Gas Producers, Perth, for supplying and fitting a "Powell" producer plant.

Mr. Herbert, for making available and fitting a "Pioneer" producer plant.

Perth Motor Garage, who supplied and fitted a "Simplex" producer plant.

Messrs. H. V. McKay, Massey Harris Ltd., for supplying a 16 Tyne Sunduke Scarifier and for their very helpful co-operation in many other directions.

*This paper was prepared by the author and submitted as a thesis to the Faculty of Engineering of the University of Western Australia and is published herewith with the consent of the Dean of the Faculty.

Mr. Pallant, Kellerberrin, who allowed his harvesting to be done under test conditions.

The Shell Oil Co., for supplying lubricating oil and power kerosene used in the Field Trials.

A second series of tests carried out at Cranmore Park, Walebing, by courtesy of E. H. B. Lefroy, Esq., are in course of preparation and will, it is hoped, be published at an early date.

(Sgd.) A. T. BOWDEN,

University of Western Australia,
November, 1939.

INTRODUCTION.

In many parts of the world in recent years, an increasing amount of attention has been paid to the possibility of using producer or suction gas as a fuel for internal combustion engines. The term producer gas is here used to cover the wide range of mixed gases that are obtained by the gasification of wood, wood charcoal, or coke. In Australia, the use of coke is negligible as the coal supplies are limited.

In most countries, America being the chief exception, solid fuels in the form of wood, peat or coal are by far the cheapest forms of fuel. To obtain power from the fuel, it is necessary to burn it. There are three ways in which a solid fuel may be used. They are:—

(1) Complete combustion.

(2) Partial gasification.

(3) Complete gasification.

As there has, up to the present, been no successful device made that enables internal combustion engines to use solid fuel, the first two methods are of little use as a means of supplying fuel for transport and agricultural purposes. It has long been realised however that gas is the ideal fuel for the internal combustion engine, and all attempts to improve the performance of the petrol engine have been based on the principle of making the petrol-air mixture behave more like a gas mixture. In the evolution of the internal combustion engine, the liquid fuel certainly presented fewest difficulties. For this reason, it was natural at a time when manufacturers were doing their utmost to make a market for their products, that they should choose a fuel that gave least trouble and the best results. Therefore, the use of producer gas as a fuel for such engines was seriously considered only at such times as the price of petrol was high.

With the drive for economic self-sufficiency that has been created in many countries to-day, the advantage of using a solid fuel has become most marked. The Australian hardwoods appear to be eminently suited for making a charcoal that gives very good results when gasified.

When the internal combustion engine was first developed at the end of the last century, and the beginning of this, the idea of a mobile power unit was only just being put into practice, while many stationary units were in use. A number of such stationary units derived their power from producer gas.

The gas plants that were made at the beginning of the century, were in every way similar to the engines that they supplied with fuel. They were big and cumbersome and were only suitable for stationary work. To apply them for mobile

work, a tractor would have to be employed to move them, and would probably make use of all the fuel they could supply for that purpose so that it would be impossible to do any other work. The stationary engines that they supplied with fuel were similar and of the slow speed type with larger cylinders and immense flywheels. Usually one cylinder was considered sufficient and the more power required the larger the cylinder. An example of such an engine is one that was built in 1904 for the purpose of driving electrical apparatus. The engine was rated at 36 h.p., the cylinder dimensions being bore 8in., stroke 15in., the flywheel weighing 3 tons. Comparing this with a modern engine with a bore of 3½in. and stroke 5in., that is built in a four cylinder unit which develops 40 h.p. and yet has a total weight of approximately 500 lbs., the improvement has been made in the engines so why not make a similar one in the gas plants? In actual practice, the high speed engine presents a far easier problem to the designer of a gas plant than does the slow speed single cylinder engine because of the more constant rate of flow of the gases. With the engines, the main difference has been to increase the speed. Similarly if plants could be made to stand up to the use of much higher rates of gasification, they could be made on a scale comparable to that of the modern high speed multiple cylinder engine.

The work has not been entirely dropped, and towards the end of the last war, many people turned their minds to the problems connected with the use of gas in place of petrol. Their work received a setback when, after the war the price of petrol fell to such an extent that there was little advantage in the use of a solid fuel, and the extra work entailed seemed to balance the saving in fuel costs. The plants produced then were good, and had there been any incentive to continue in the manufacture on them for a few more years, there is no doubt that they would have produced a plant worthy of the modern car or truck engine.

In the last few years, the price of wheat has been falling in a steady but alarming manner. For this reason, several farmers started experimenting with the use of gas in their tractors to see if it were possible to lower their costs of production and so meet the lower wheat prices. Of the number who started working with only a rough idea of how the plants could be made, some had such highly satisfactory results that their neighbours persuaded them to make similar plants for them.

It so happened that these men found more interest in the manufacture of gas plants than in farming and so set out to make them on a commercial basis. It is needless to say that the greatest asset to this new industry was the oxy-acetelene welding process that enabled gas-tight seams to be made in sheet metal that would be unaffected by very high temperatures without having to resort to heavy plating with riveted and caulked joints that were always liable to buckling under the stresses set up by extremes of temperatures. However at first these pioneers were just doing what had previously been done in the other parts of the world. At the present time, they seem to have reached a stage that compares very favourably with that reached by the European countries.

At this stage, it was thought advisable to have some definite information gathered by unbiased observers, concerning the performance of tractors fitted with such plants. This would then enable the manufacturers to see along what lines further improvements were necessary, and at the same time let the farming community know exactly what benefits could be expected from the use of gas and the corresponding drawbacks so that a definite opinion could be formed as to whether gas would suit their requirements or not. To this end a tractor of fairly popular make was procured and its maximum power output using kerosene was obtained. Then as many of the local gas plants as could be obtained were fitted in turn to

the engine, and the maximum power output obtained in each case. All these tests were done in the laboratory of the Engineering School of the University of Western Australia. A selection of these plants were then tried under actual field conditions at Kellerberrin, the results of these trials being the basis of this report.

FIELD TESTS.

To determine tractor performance under field conditions, tests were made over a working period of about six months between September 1938 and March 1939. Farming operations undertaken included ploughing, stripper harvesting, cutting and binding, cultivating and scarifying. Owing to the seasonal period over which the tests were made, ploughing and to a certain extent cultivating, could not be done under normal working conditions, the ground being too dry and hard. Accordingly this point should be kept in mind where figures relating to such factors as drawbar horsepower and relative performances as between steel wheels and rubber tyres are concerned.

The tests were conducted on the property of F. Mather, Esq., of Kellerberrin, with the exception of the stripper harvesting which was done on the property of G. Pallant, Esq., also of Kellerberrin. The land consisted for the most part of sandy loan with irregular patches of blue clay, and was officially classed as salmon gum country.

Object of Tests.

The tests were designed to provide information relating to the performance of producer gas driven tractors working under Western Australian field conditions. Specific data was sought under the following headings:—

(1) Fuel consumption and power output.

(2) Comparison of performance when using—
  (a) Rubber tyres.
  (b) Steel wheels with spade lugs.

(3) Comparison of power output when using high and low compression pistons.

(4) Performance compared with that obtainable when using kerosene under comparable working conditions.

(5) Lubricating oil consumption and analysis.

(6) Cylinder wear.

(7) General observations of time and labour factors associated with usage of producer gas.

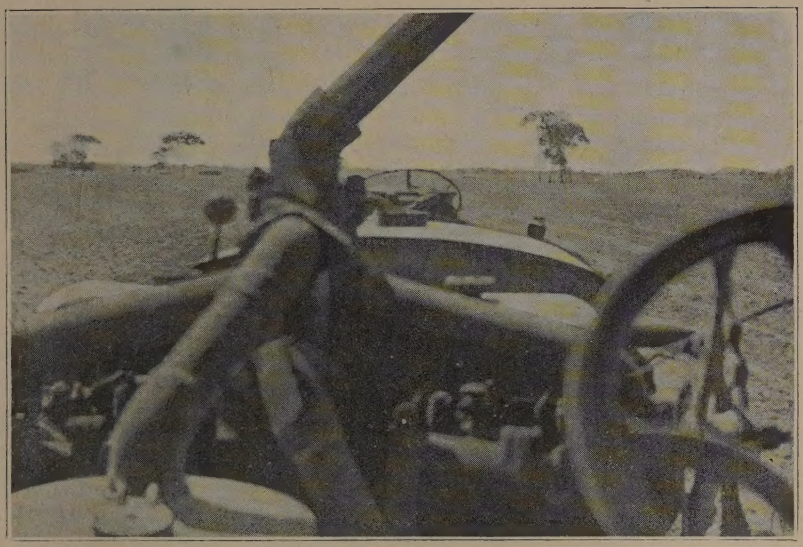
(8) Comparative analysis of working costs.

Details of Plant Used in Tests.

Tractor.

With the exception of the special tests carried out on an "Allis-Chalmers" Model "U" tractor and listed separately, all tests were made with a reconditioned "Case" Model "A" 12/20 tractor.

Apart from alteration of magneto timing to suit producer gas operation with fitting of special spark plugs, and high compression pistons, no structural alterations were made to the standard tractor.



Block 1.
The "Case" 12-20 fitted for Kerosene.

Block 2.

Tractor Specifications:

Cylinders	4 Vertical.
Bore	4⅛in.
Stroke	5in.
Rated R.P.M.	1,050.
Gear Ratios	High = 49:1. Low = 66.6:1. Reverse = 98:1.

Corresponding to speeds of 3 m.p.h., 2.2 m.p.h., 1½ m.p.h.

Total weight as fitted for burning kerosense: 4,450 lbs.

Rated Output:

Engine: Brake horsepower 20.
Drawbar- horsepower (Steel Wheels) 12.
Draw-bar horsepower (Rubber Tyres) not rated.

Dynamometer tests carried out at the School of Engineering of the University of Western Australia prior to the field tests gave a maximum continuous output of 23.75 brake horsepower.

Producer Units.

The producer units used in the tests were standard units of types made and marketed in Western Australia. The units were supplied and fitted to the tractor by the makers, who supplied exhaust and inlet manifolds, and such other fittings as in their opinion were considered desirable.

Three types of producer plant were tested, comprising:—

(1) "Powell."
(2) Herbert "Pioneer."
(3) "Simplex."

(1)—*"Powell": Brief specifications:*

Total weight 450 lbs.

Generator—Overall dimensions 4ft. 6in. x 18in. Up-draught, double shell, constant length flame path type; 3-point gas take-off, firebox 3/16 M.S. plate; shell 1/16 M.S. plate; grate, cast iron. Powell Patent Cross-section: Area of firebox 1.262 sq. ft. Length of flame path 18 inches. Maximum rate of gasification 34.8 cu. ft. per minute per square foot of firebox.

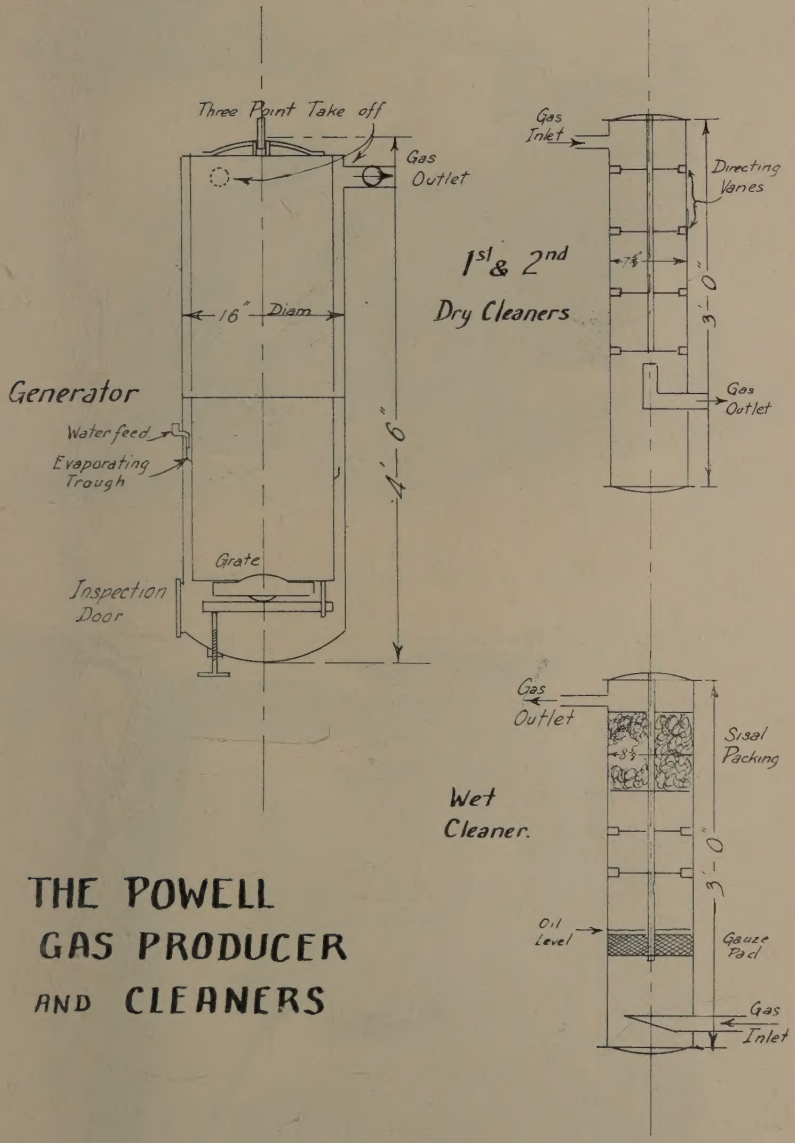
Cleaners—2 dry cleaners each 3ft. x 7⅝in. diameter, windmill type downward flow. One oil cleaner 3ft. x 8⅝in. diameter. Powell patent upward flow of gas and oil vapour past windmill vanes to sisal hemp dryer.

Cooler—None.

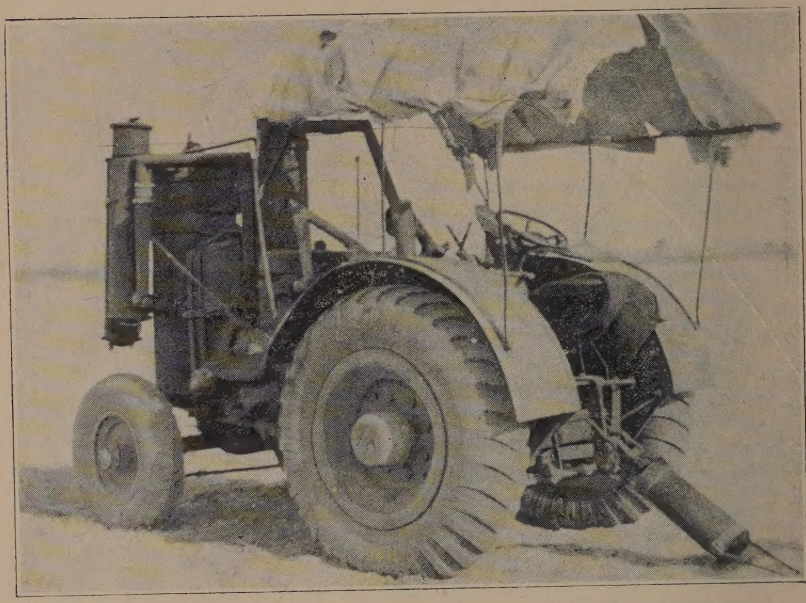
Situation on tractor—Generator in front of radiator. Dry cleaners on left of generator in front of radiator. Oil cleaner in position usually occupied by kerosene tank between radiator and engine above fan.

Controls—Water control. Drip feed; hand controlled valve situated under tank attached to generator. Extension rod brings control to driving position.

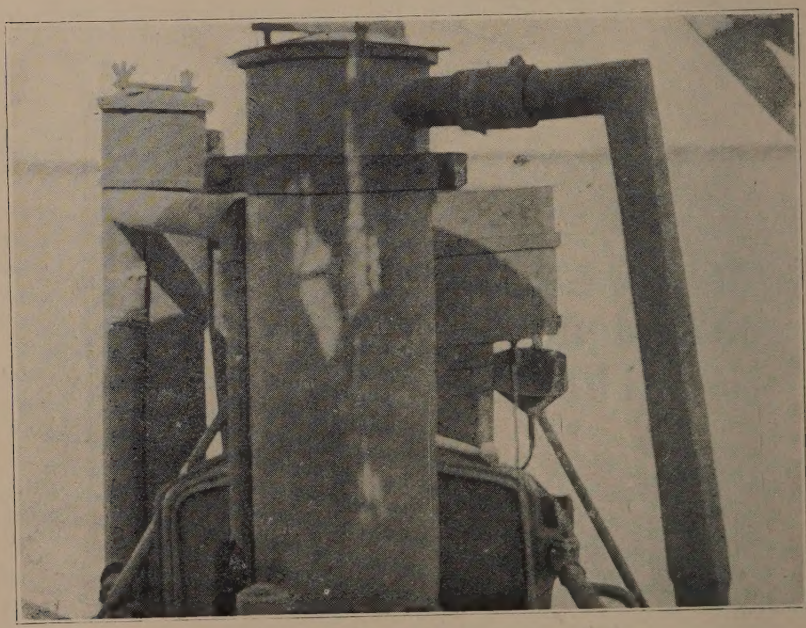
Air and gas control—Butterfly valves set in the air and gas lines controlled by hand levers set near petrol throttle and spark control levers.


Three Point Take off
Gas Outlet
16" Diam
4'-6"
Generator
Water feed
Evaporating Trough
Grate
Inspection Door
Gas Inlet
Directing Vanes
1st & 2nd
Dry Cleaners
3'-0"
Gas Outlet
Gas Outlet
Sisal Packing
Wet Cleaner.
3'-0"
Oil Level
Gauze Pad
Gas Inlet
THE POWELL
GAS PRODUCER
AND CLEANERS

Block 3.



Block 4.
The "Case" 12 20 fitted with "Powell" Gas Producer.

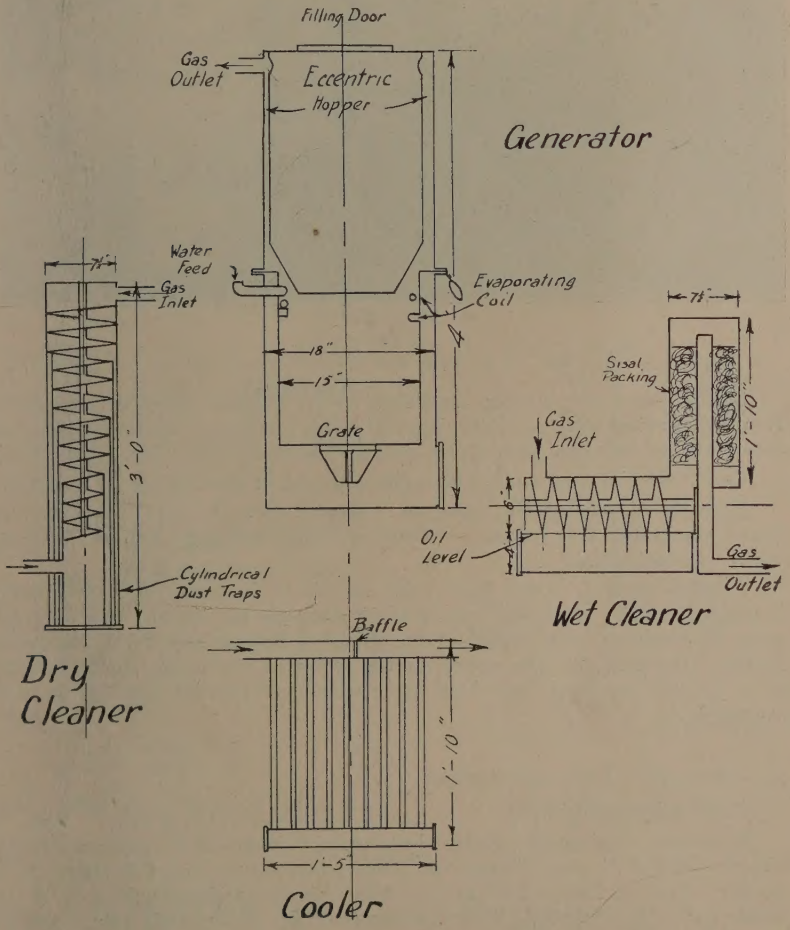


Block 5.

(2)—*Herbert "Pioneer"*: *Brief specifications*:

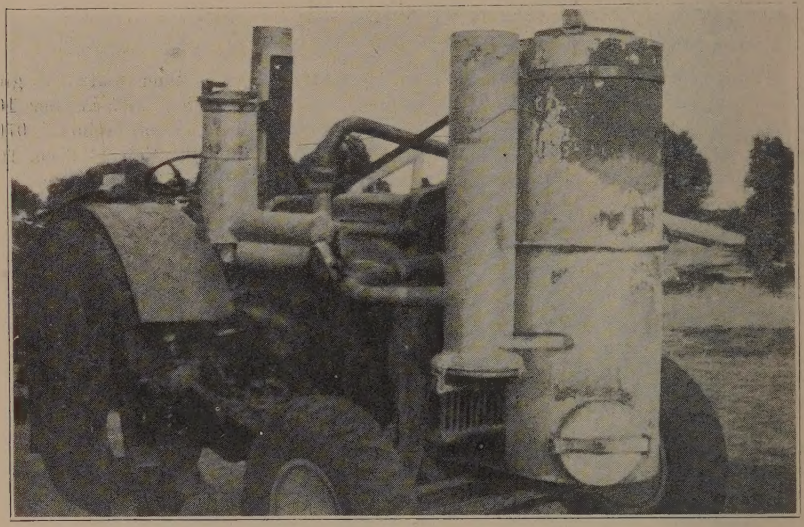
Total weight 336 lbs.

Generator—Up-draught; double shell; constant length flame path; single point take-off; eccentric hopper. Firebox $\frac{1}{8}$ M.S. plate. Shell and hopper 16 S.W.G. M.S. plate. Grate, cast iron slotted cone shaped. Area of firebox 1.070 sq. ft. Length of flame path 13½ inches. Max. rate of gasification 34.6 cu. ft. per minute per sq. ft. of firebox. Overall dimensions: 4ft. x 18in. diameter.



THE PIONEER GAS PRODUCER AND CLEANERS

Block 6.



Block 7.
The "Case" 12-20 fitted with "Pioneer" Gas Producer.

Cleaners—One dry cleaner, centrifugal; vertical spiral attached to generator. Overall dimensions: 3ft. x 7½in. diameter. One oil cleaner, horizontal spiral on contact with oil with sisal hemp dryer. Overall dimensions: 2ft. x 6in. x 2ft. x 7½in.

Cooler—Double flow multi-tube radiator placed in front of engine radiator.

Situation on tractor—Generator on reinforced plate in front of tractor. Dry cleaner attached to side. Cooler in front of engine radiator. Oil cleaner alongside the kerosene tank.

Controls—Water. Drip feed; valve at side of kerosene tank which serves as water reservoir. Adjusted from ground alongside the tractor. For test purposes, an extension control enabled the water to be regulated from the driving position. Gas and air: The petrol throttle serves as air control; butterfly valve, set in gas line operated from hand lever near spark control lever, controls the gas supply.

(3)—*"Simplex"*: *Brief specifications*:

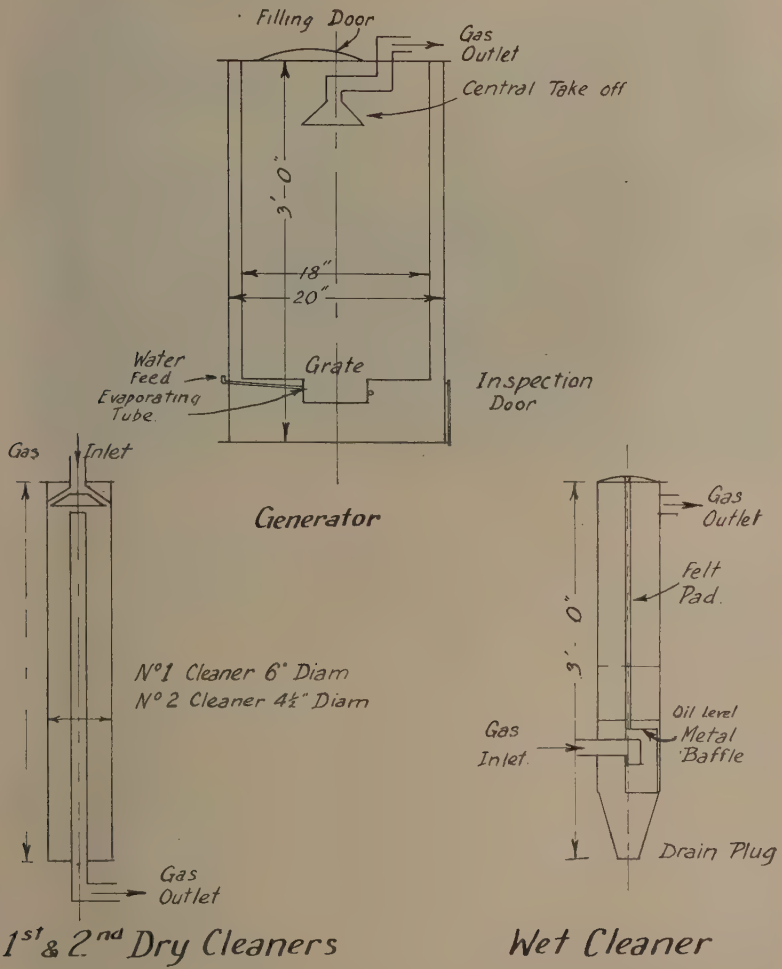
Total weight 280 lbs.

Generator—Updraught; double shell; variable length flame path; central gas take-off. 18 S.W.G. plate throughout. Grate: tuyere type with C.I. heavy section fire bar. Area of firebox 1.77 sq. ft. Max. rate of gasification 20.9 cu. ft. per minute per sq. ft. of firebox. Overall dimensions: 2ft. 8½in. x 2ft. 10in. x 3ft. 6in.

Cleaners—Two dry cleaners employing a downwards and outwards rotary motion of the gas to effect the separation of the dust from the gas. One oil cleaner employing a felt filter pad kept moist with oil vapour collected by passage of the gas through an oil bath.

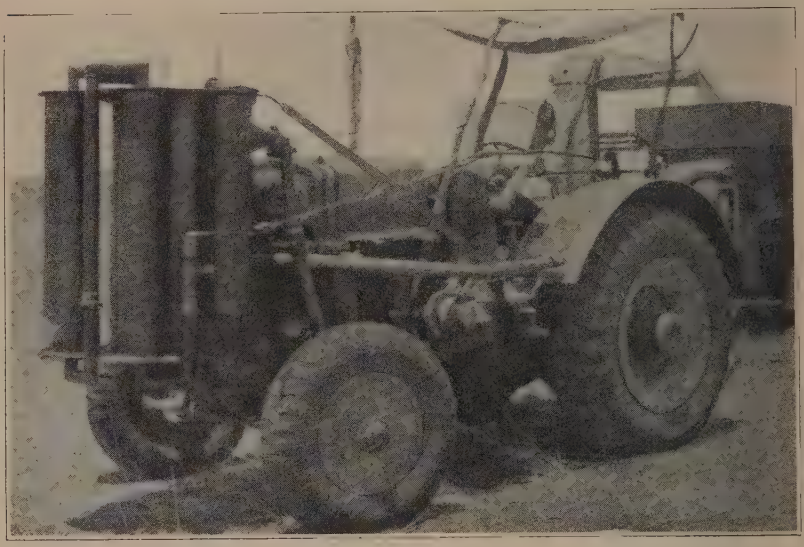
Cooler—None.

Situation on tractor—Generator with cleaners grouped round it situated on common base and top-plates in front of radiator.



THE SIMPLEX GAS PRODUCER AND CLEANERS.

Block 8.



Block 9.
The "Case" 12-20 fitted with "Simplex" Gas Producer.

Controls—Water. Valve under kerosene tank controls drip-feed. Air: situated between second dry cleaner and oil cleaner adjustable from in front of tractor. Gas: gate valve in gas line controls amount of mixture—can be reached from driving position.

Implements.

(1) Ploughs:

(a) 5-furrow Smith type mouldboard plough, stump jump steel frame.

(b) 8-furrow Smith type mouldboard plough, stump jump steel frame.

(2) Scarifier—16-tyne "Sunduke" scarifier made by H. V. McKay, Massey-Harris Ltd., steel frame, stump jump, rigid tyne, spring controlled.

(3) Harvester—"Sunshine" 10ft. "E" type stripper harvester made by H. V. McKay-Massey-Harris Ltd.

(4) Binder:

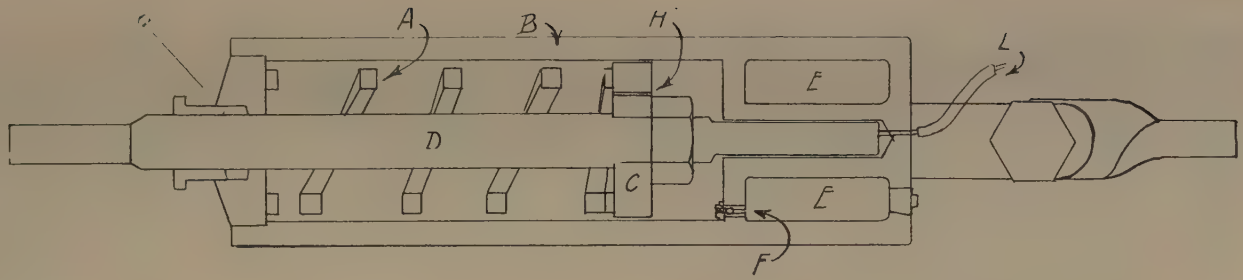
(a) 8ft. cutter and binder made by McCormick-Deering Co.

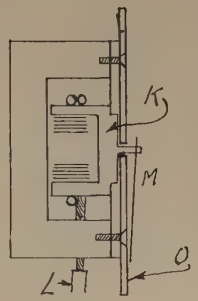
(b) 8ft. cutter and binder made by H. V. McKay, Massey-Harris Ltd.

METHOD OF CONDUCTING TESTS.

(a) *General.*

In order that the useful power output might be divided from the total power output, no-load tests were run over prolonged periods as grounds and climatic conditions changed appreciably.





TRACTION DYNAMOMETER.

Block 10.

(b) *Draw-Bar Pull.*

The implements used in the tests were coupled to the tractor through a traction dynamometer. Observations of the pull were recorded at regular five minute intervals.

During the initial stages of the tests, two types of dynamometer were successively used—the Chatillon Dynamometer operating on the principle of the variation in length under load of the minor axis of an elliptical spring, and the Salter balance using four coil tension springs in parallel. Frequent checks showed that both types were unsuited to continuous operation on account of wear in the recording mechanism and therefore a special instrument designed in the Department of Mechanical Engineering of the Engineering School was adopted.

As shown in Fig. 10 the dynamometer consists of a single heavy coil spring A, working in a completely oil filled cylinder B against a piston C coupled through a piston rod D to the tractor. The oil reservoir E communicates with the main cylinder through the non-return valve F and so enables leakage through the gland G to be made up. Small holes H in the piston enable the oil in the cylinder to dampen small rapid variations in pull.

The movement of the piston rod D is communicated to the spring loaded drum K of the recording mechanism through the Bowden cable L. Attached to the drum K, the adjustable pointer M works over the calibrated dial O.

The dynamometer was continuously coupled to the tractor and frequent checkings showed consistent accuracy.

(c) *Tractor Speed.*

The method adopted for computing the speed and distance covered was based on the assumption that no slipping of the front wheels takes place under normal working conditions. By a simple trigger mechanism, the revolutions of the front wheels were taken to a revolution counter housed conveniently near the driving seat. The revolutions were read every five minutes concurrently with the load as recorded on the dynamometer. The distance travelled in terms of front wheel revolutions was checked against actual measurement as change of country and weather conditions demanded.

(d) *Fuel Consumption.*

(1) *Charcoal*: All fuel was weighed immediately before being put into the hopper. At the end of the period over which the consumption test was being made, the generator was completely emptied and the residue weighed—all weights being made on a steelyard and the weight of the containers being deducted.

(2) *Water*: The weight of water put in the tank every morning before starting was noted. The residue remaining at the end of the period of work being weighed and the difference giving the weight of water used.

(3) *Petrol*: The petrol put in the tank was weighed but the tank was not drained regularly. Petrol was added when the quantity in the tank was less than one pint.

(4) *Kerosene*: The kerosene was weighed as it was put in the tank, and the residue at the end of the test period drained and weighed.

(e) *Maximum Load Tests.*

These were carried out at intervals during the tests and finally a comparative maximum load test was made for which all plants were tested for their maximum load within a week in order to obtain similar conditions.

To obtain the maximum load, readings of the dynamometer and revolution counter were taken every half-minute. As it was found that while the maximum power output occurred at the working speed, but a considerably greater pull could be maintained at a lower speed, three sets of readings were taken.

(a) Maximum power: Maximum pull at working speed of tractor from readings taken at half-minute intervals.

(b) Maximum pull: Maximum pull at a constant speed that could be maintained, but which was definitely less than working speed.

(c) Stalling load: Pull which would stop the tractor in just under half a minute.

(f) *Oil Consumption and Method of Sampling.*

Oil samples were taken at regular intervals from the crankcase of the engine always after the engine had been working, and generally with the engine running to ensure a representative sample.

Replenishing of the oil was done after the sample had been taken. The oil from each test was taken from the one tin and the quantity of oil used being calculated at the end of the test. This method was adopted as the samples taken were so small that any field method of computing the amount of oil taken out or replaced would have been very inaccurate.

The samples were analysed by Messrs. D. C. Dodd and E. E. Jarvis at the University of Western Australia.

(g) *Cylinder Wear.*

An Ames cylinder barrel gauge was used to measure the wear in the cylinder. This measurement was made after every test period with each plant. The measurements were made at three points in the barrel—at the top; at the mid-point; at the bottom. In each of these places, readings were averaged and the mean taken as the diameter in each point.

RESULTS OF TESTS.

Power and Consumption Tests with Producer Gas.

General: In recording the results of the power and consumption tests, the daily log sheets (of which a specimen is shown on page 386), have been summarised to show the average figures for the complete daily run. General remarks relating to plant behaviour and features deserving special note have been retained in full as observed.

Fuel: White gum charcoal ex Chidlow, Western Australia. Retort burned by W. Somerville, cost £2 5s. per ton f.o.r. Chidlow.

The charcoal fuel used throughout the test was received in one batch from the manufacturer and was representative of a reasonably clean well-burned charcoal.

Specimen Page of Log.

PRODUCER GAS FIELD TRIALS AT KELLERBERRIN, W.A.

Date: Tuesday, 11th October, 1938. Plant: "Powell" (Rubbers).

Time.	Load.	Revs.	Remarks.	Time.	Load.	Revs.	Remarks.
8·43	...	54,749	Starting.	1·40	1,300	59,542	On gas 2 min.
8·45	1,400	54,798		1·45	1,600	59,637	
8·48	...	54,864		1·50	1,800	59,733	
8·50	1,000	54,924		1·55	1,800	59,842	
8·55	1,400	55,013		2·00	1,900	59,948	
9·00	1,800	55,147		2·10	1,500	60,108	
9·05	1,800	55,285		2·15	1,500	60,262	
9·10	1,700	55,384		2·20	2,000	60,416	
9·15	1,900	55,552		2·25	1,700	60,571	
9·20	1,300	55,687		2·30	1,500	60,728	
9·25	1,500	55,830		2·35	2,000	60,886	
9·30	1,700	55,966		2·40	1,600	61,040	
9·35	1,400	56,109		2·45	1,400	61,197	
9·40	2,000	56,214		2·50	1,500	61,354	
9·45	1,500	56,351		2·55	1,300	61,510	
9·50	1,800	56,473		3·00	1,600	61,667	
9·55	1,500	56,654		3·05	2,000	61,811	
10·00	1,000	56,775		3·10	2,000	61,924	
10·09	1,500	56,829		3·15	1,800	62,053	
10·10	1,500	56,829		3·25	1,800	62,215	
10·15	1,700	56,977		3·30	2,000	62,299	
10·20	1,900	57,120		3·35	2,000	62,414	
10·25	1,700	57,277		3·40	2,000	62,535	
10·30	1,500	57,459		3·50	2,100	62,771	
10·40	1,600	57,740		3·55	1,400	62,900	
10·41	30	...	Off Load 3½ min.	4·00	1,000	62,962	
10·50	1,600	57,890		4·05	1,400	63,102	
10·55	1,600	57,992		4·10	1,500	63,250	
11·00	1,500	58,146		4·15	2,000	63,383	
11·05	1,500	58,296		4·20	1,900	63,510	
11·10	2,000	58,444		4·26	1,800	63,625	
11·15	1,600	58,594		4·30	1,800	63,735	
11·20	1,400	58,721		4·35	1,500	63,873	
11·25	1,300	58,820	Off Load 6 min.	4·40	1,700	63,984	
11·35	1,800	58,940		4·45	1,600	64,107	
11·40	2,000	59,082		4·50	1,800	64,235	
11·45	1,600	59,255		4·55	1,900	64,363	
11·50	2,000	59,379		5·00	2,100	64,485	
12·00	1,400	59,534	Stop.	5·05	1,300	64,593	
				5·10	1,500	64,761	

		lbs.
Fuel put in:	Charcoal (56, 30¾, 60¾, 60)	207½
	Water	42½
Taken out:	Charcoal	38¾
	Water	½

Tyre Pressures: 12, 12½.
On Gas: 4 minutes.
Average Load: 1,650 lbs. corrected 1,890 lbs.
Average Speed: 27·6 r.p.m. = 3·47 ft. per second.

Time of Working.		Fuel consumed:	
hrs.	min.	105½ lbs.	charcoal.
6	35	38¼ lbs.	water.
148	16		
154	51		

GROUP 1.

SERIES A.

Using high compression and rubber tyres.
Pistons: Cast iron normal construction giving compression ratio 7.8 : 1.
Ignition advance: 20° of engine crankshaft.
Tyres: Barnet Glass, 4 ply. 11.25 x 24.
Wheels and Rims: Cast iron one piece heavy section.

SERIES A (1).—"POWELL" GAS PLANT USING HIGH COMPRESSION AND RUBBER TYRES.

Spark Plugs:—Leggetts "L-4" (9-9-38—6-10-38) Pyrox PZ 30K (6-10-38—15-10-38).

Date.	Time of Working.	Average Load.	Average Speed.	Average Draw-bar.	Time on Petrol.	Petrol Used.		Fuel Used: Total.	Fuel Used: Per d.b.h.p. hr.	Fuel Used: Per Acre.	Water Used: Total.		Water Used: Per d.b.h.p. hr.	Per lb. Fuel.	Area Worked.	Remarks.
	min.	lbs.	ft./sec.	H.P.	min.	lbs.	gal.	lbs.	lbs.	lbs.	lbs.	gal.	lbs.	lbs.	acres.	
(a) Ploughing—																
9-9-38	448	785	4·13	5·9	10	12¾	1·6	137·0	3·12	23·8	....	....	....	.	5·77	Water not checked at end.
10-9-38	235	742	4·01	5·41	4	....	..	69·5	3·25	22·8	29·0	2·9	1·364	0·418	3·05	
12-9-38	155	703	4·44	5·67	4	....	..	61·0	4·16	28·2	17·25	1·725	1·175	0·283	2·085	
13-9 38	459	822	3·94	5·89	8	..	..	184·0	4·09	24·1	12·75	1·275	0·283	0·0693	7·65	8 Furrow Plough.
14-9-38	418	1,028	4·01	7·5	11	9·0	1·128	145·25	2·775	22·4	10·0	1·0	0·191	0·0688	6·5	7 Furrow Plough.
16-9-38	157	1,100	4·1	8·2	6	....	..	77·0	3·56	21·9	2·0	0·2	0·093	0·026	3·06	
10-10 38	133	1,920	4·13	14·41	6	10·0	1·26	91·5	2·86	30·8	15·25	1·525	0·478	0·166	2·97	8 Furrow Plough.
11-10 38	367	1,890	3·47	11·93	6	..	....	165·5	2·26	23·9	38·25	3·825	0·535	0·231	6·92	
12-10-38	326	1,878	3·41	11·63	11	....	..	146·5	2·3	24·4	29·25	2·925	0·464	0·1985	5·97	
(b) Binding—																
27-9 38	300	635	4·09	4·73	12	..	....	110·5	4·71	10·78	15·5	1·55	0·655	0·1388	10·25	
28-9-38 ..	396	609	4·15	4·59	8	....	....	134·5	4·44	10·05	13·65	1·365	0·45	0·1013	13·4	Engine not stopped all day.
29-9-38 ..	336	607	4·17	4·6	9	6·0	0·756	130·5	5·06	10·4	23·25	2·325	0·902	0·178	12·5	
30-9-38	551	583	4·15	4·40	11	....	....	145·5	3·6	7·275	8·5	0·85	0·199	0·0553	20·0	
1-10-38 ..	496	580	4·17	4·40	9	4·5	0·567	159·5	4·39	9·2	24·5	2·45	0·675	0·1535	17·3	
3-10-38	479	585	4·21	4·47	12	....	..	161·5	4·63	9·65	19·5	1·95	0·0546	0·195	17·85	
4-10-38	431	580	3·9	4·12	10	10·0	1·26	162·5	5·51	10·88	20·5	2·05	0·695	0·126	14·95	
5-10-38	383	590	4·1	4·4	9	....	..	158·0	5·62	10·41	27·0	2·7	0·96	0·171	15·17	
6-10-38	424	600	4·16	4·54	5	....	....	159·0	4·97	9·2	20·7	2·07	0·645	0·1253	17·31	Spark Plugs Changed
7-10-38	317	871	4·16	6·58	8	8·0	1·01	139·5	4·02	10·82	41·0	4·1	1·18	0·293	12·88	40 min. scarifying.
8-10-38	321	590	4·14	4·44	7	3·0	0·379	142·0	5·99	10·83	64·5	6·45	2·72	0·454	13·1	
13-10-38	135	606	4·09	4·5	5	....	..	73·0	7·21	10·5	11·0	1·1	1·88	0·151	6·95	
(c) Cultivating—																
14-10-38	299	902	3·96	6·5	6	7·6	0·9	133·0	4·1	11·7	13·25	1·325	0·409	0·0995	11·38	
(d) No. Load Tests—																
12-9-38	161	....	4·4	....	4	....	....	41·0	13·4 (lbs./hr.)	0·058 (lbs./ch.)	14·25	1·425	....	....	735 chs.	
(e) Maximum Load Test—																
16-10-38	40	Max Load at 4·14 ft./sec., 2,100 lbs. = 15·8 d.b.h.p.						Maximum Pull 2,300 lbs at 3·02 ft./sec. = 12·6 d.b.h.p.; stalling load = 2,680 lbs.								
27-1-39	53	,, ,, 4·3 ft./sec., 1,900 lbs. = 14·85 d.b.h.p.						,, ,, 2,128 lbs. at 2·5 ft./sec. = 9·7 d.b.h.p.; stalling load = 2,465 lbs.								

Remarks.—The high fuel consumption when working on the light load of binding is accounted for by the high proportion of the engine power developed that is required to propel the tractor, *e.g.*, taking 3-10-38.

The fuel used per hour 20·2 lbs., fuel required to propel the tractor per hour 13·4. Therefore fuel per hour used for work 6·8 lbs. or 1·52 lbs. per h.p.hr., which agrees with the consumption figures obtained from the bench tests.

SERIES A (2)—HERBERT "PIONEER" GAS PLANT USING HIGH COMPRESSION AND RUBBER TYRES.

Spark Plugs: KLG. 669J.

Date.	Time of Working.	Average Load.	Average Speed.	Average Draw-bar.	Time on Petrol.	Petrol Used.		Fuel Used.			Water Used.			Area Worked. Acres.	Remarks.
								Total.	Per d.b.h.p. hr.	Per Acre hr.	Total.	Per d.b.h.p. hr.	Per lb. Fuel.		
	min.	lbs.	ft./sec.	H.P.	min.	lbs.	gal.	lbs.	lbs.		lbs.	lbs.	lbs.	acres.	
(a) Scarifying—															
2–11–38	312	1,700	3·93	12·15	7	....	....	152·0	2·4	12·71	29·0	0·466	0·191	11·95	
3–11–38	437	1,840	3·9	13·05	7	9·75	....	174·0	1·83	9·95	42·0	0·442	0·241	17·48	
4–11–38	463	1,770	4·04	13·0	9	....	....	168·0	1·676	10·25	46·0	0·459	0·274	16·38	
5–11–38	174	1,960	4·07	14·5	10	....	....	115·0	2·71	16·95	20·0	0·477	0·174	6·8	
14–11–38	157	1,405	3·99	10·18	18	....	....	81·0	3·05	11·84	10·0	0·376	0·1235	6·85	Jarrah Charcoal.
(b) Harvesting—															
10–11–38	335	1,280	4·07	9·47	18	....	....	141·5	2·67	8·75	35·0	0·663	0·247	16·15	
11–11–38	340	1,335	3·96	9·6	19	8	....	131·25	2·28	7·9	31·0	0·538	0·236	16·63	
12–11–38	147	1,350	4·1	10·05	5	....	....	47·0	1·91	6·3	10·0	0·407	0·213	7·46	
15–11–38	355	1,040	4·0	7·57	7	....	....	177·0	....	....	26·25	....	....	18·0	Firebox not emptied.
16–11–38	269	970	4·07	7·35	11	10·75	....	122·0	3·35	8·1	15·5	0·552	0·165	15·85	
17–11–38	317	1,065	4·04	7·8	8	....	....	99·5	....	....	24·0	....	....	....	Consumption figures for 3 days.
(c) No. Load Test—															
21–11–38	158	....	4·1	....	7	....	....	44·0	16·7 (lb./hr.)	....	4·5	1·71 (lb./hr.)	....	702 ch.	
(d) Maximum Load Test—															
25–11–39	57	Maximum Power at 4·3 ft./sec., 2,018 lbs. = 15·4 d.b.h.p.													Maximum Pull 2,350 lbs. at 2·5 ft./sec., = 10·7 d.b.h.p. Stalling Load 2,580 lbs.
14–11–38	30	Maximum Power at 4·14 ft./sec., 2,100 lbs. = 15·7 d.b.h.p.													Maximum Pull 2,200 lbs. at 2·6 ft./sec., = 10·6 d.b.h.p. Stalling Load = 2,610 lbs.

SERIES A (3)—"SIMPLEX" GAS PLANT USING HIGH COMPRESSION AND RUBBER TYRES.

Spark Plugs—AC (28-11-38—14-1-39); KLG. PKA 3 (16-1-39—26-1-39).

Date.	Time of Working.	Average Load.	Average Speed.	Average Draw-bar.	Time on Petrol.	Petrol Used.		Fuel Used.			Water Used.			Area Worked.	Remarks.
								Total.	Per d.b.h.p. hr.	Per Acre.	Total.	Per d.b.h.p. hr.	Per lb. Fuel.		
	min.	lbs.	ft./sec.	h.p.	min.	lbs.	gals.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	acres.	
(a) Harvesting—															
28-11-38	288	1,100	4·06	8·12	21	6·0		179·0			44·5			14·75	Fuel consumption over 2 days.
29-11-38	274	1,170	3·97	8·44	12	12·0		71·0	3·2	9·72	10·75	0·71	0·221	13·45	
30-11-38	279	1,220	4·13	9·15	10			184·0	2·55	7·6	41·5	0·894	0·351	14·25	
1-12-38	259	1,220	4·04	8·95	33	9·5		22·5			31·0			12·92	Plugs fouled with oil (12·15)
2-12-38	314	1,160	4·105	8·66	22			173·5	3·25	9·06	34·25	0·828	0·255	15·9	
3-12-38	228	1,115	4·095	8·3	15	11·0		75·75			29·25			11·55	
5-12-38	367	1,120	4·11	8·37	12			111·0	2·17	5·94	29·5	0·576	0·266	18·67	
6-12-38	388	1,120	4·12	8·39	8			196·0	2·365	6·15	51·5	0·715	0·305	19·8	
7-12-38	236	930	4·07	6·99	27	9·0		3·0			13·75			11·9	
8-12-38	276	1,120	4·1	8·35	23			184·0			32·25			14·0	
9-12-38	265	1,120	4·09	8·33	21	9·0		69·0	2·55	7·1	40·0	0·73	0·285	13·4	
10-12-38	161	1,185	4·13	8·9	11									8·23	
12-12-38	342	1,440	4·12	10·78	18	12·0		182·0			35·75			17·4	Harvesting on slope.
13-12-38	196	1,125	4·1	8·36	13			178·0	2·62	7·7	42·5	0·735	0·281	9·95	Havester trouble.
14-12-38	298	1,160	4·09	8·64	26			65·0			37·25			15·06	Cultivating, 9-1 p.m.
15-12-38	348	1,060	4·08	7·88	32			29·0			15·0			17·6	Fire box burned out, 6·45 p.m.
(b) Cultivating—															
13-1-39	118	1,170	4·09	8·70	7			125·0	4·45	16·13	32·0	1·98	0·445	4·77	Maximum continuous load, 1,460 lbs.
14-1-39	82	1,150	4·08	8·53	4			3·0			25·0			3·21	
16-1-39	273	1,355	4·07	10·0	12			166·0	2·72	12·1	55·25	0·9	0·331	10·68	New Plugs. Maximum load, 1.750 lbs.
17-1-39	78	1,619	4·05	11·9	10									3·03	
(c) Maximum Load Tests—															
17-1-39	Maximum Load at 4·1 ft. sec., 1,760 lbs. = 13·1 d.b.h.p.							Maximum Pull at 2·5 ft./sec., 1,950 lbs. = 8·85 d.b.h.p.						Stalling Load = 2,100 lbs.	
23-1-39	Maximum Power at 4·2 ft., sec., 1,900 lbs. = 14·5 d.b.h.p.							Maximum Pull at 2·5 ft./sec., 2,240 lbs. = 10·2 d.b.h.p.						Stalling Load = 2,470 lbs.	

Remarks.—The condition in the firebox which enabled these maximum Loads to be obtained lasted for 20 minutes only under test with each filling.

The results of the no-load tests have not been generally used in conjunction with the normal tests to give the fuel consumption per B.H.P. hour developed by the engine as the various consumption figures show the extent by which the fuel consumption varies. Under no-load conditions there is no indication that the fuel consumption per unit of work will be the same as at full load. In one instance only, was the result of the no-load test used. In the process of reaping and binding with small machines, the load was very light and the power required to drive the tractor formed a large proportion of the total output. In this case the result of the no-load test serves to show that there is not a considerable difference between the consumption at high and low loads. It can however be only taken as an indication and not as definite proof.

SERIES B.

Using high compression and steel wheels.

Pistons: Cast iron normal construction giving compression ratio 7.8 : 1.

Ignition Advance: 20° of engine crankshaft.

Steel Wheels: Standard Case designed fitted with:

(1) Powell Gas Plant.

(2) Herbert Gas Plant.

(3) Simplex Gas Plant.

SERIES B.—(1) POWELL GAS PLANT USING HIGH COMPRESSION AND STEEL WHEELS.

Date.	Time of Working.	Average Load.	Average Speed.	Average Draw-bar.	Time on Petrol.	Petrol. Used.		Area Worked.	Fuel Used.			Water Used.			Remarks.
									Total.	Per d.b.h.p. hour.	Per acre.	Total.	Per d.b.h.p. hour.	Per lb. Fuel.	
	min.	lbs.	ft./sec.	H.P.	min.	lbs.	gals.	acres.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
(a) Ploughing—															
19-9-38 ..	255	720	4·29	5·5	8	4	....	3·85	157·0	6·7	40·75	4·25	0·1815	0·0275	Back-firing occurred when more water was used.
23-9-38 ..	95	710	2·76	3·66	6	....	....	3·0	3·9	7·1	15·3	1·5	0·273	0·0385	Work very shallow.
(b) No Load—															
22-9-38 ..	135	....	4·67	....	4	10·5	....	570 ch.	41·0	18·25 lbs./hr.		13·0	5·78 lbs./hr.	0·317	Lugs not bedding into ground.
15-10-38	142	....	4·63	....	5	....	....	597 ch.	42·0	17·73 lbs./hr.		10·0	4·22 lbs./hr.	0·238	Lugs not bedding into ground.
(c) Max. Load—															
27-1-39 ..	73	Max. Load, 986 lbs. at 5·1 ft./sec. = 8·3 d.b.h.p.							Max. Pull 1,120 lbs. at 3 ft./sec. = 6·1 d.b.h.p.						Stalling load = 1,344 lbs.
(2) HERBERT GAS PLANT.															
(a) Scarifying—															
7-11-38	293	950	4·02	6·95	8	....	....	11·28	137·5	4·06	12·2	8·0	0·236	0·0582	
(b) Max. Load—															
7-11-38	Max. Load, 1,365 lbs. at 4·16 ft./sec. = 10·33 d.b.h.p.								....	....	....	....	....	....	Stalling load = 1,590 lbs.
25-11-38	Max. Load, 1,120 lbs. at 5·15 ft./sec. = 10·5 d.b.h.p.								Max. Pull 1,345 lbs. at 3 ft./sec. = 7·35 d.b.h.p.						Stalling load = 1,570 lbs.
(3) SIMPLEX GAS PLANT.															
(a) Max. Load—															
23-1-39	58	Max. Load at 4·2 ft./sec., 1,120 lbs. = 8·55 d.b.h.p.							....	....	....	....	....	....	Stalling load = 1,350 lbs.

SERIES C.—USING LOW COMPRESSION AND RUBBER TYRES.

Pistons—Standard as supplied by tractor makers for use with Kerosene. Cast Iron—Compression ratio 3.8 : 1. Ignition Advance 45° of engine crankshaft. Plugs K.L.G. PKA. 3. (1) Powell Plant. (2) Herbert Plant. Cultivating only was done with this equipment.

Date.	Time of Working.	Average Load.	Average Speed.	Average Drawbar.	Time on Petrol.	Petrol Used.	Area Worked.	Fuel Used.			Water Used.			Remarks.
								Total.	Per d.b.h.p. hour.	Per acre.	Total.	Per d.b.h.p. hour.	Per lb. Fuel.	
(1) POWELL.														
	min.	lbs.	ft./sec.	H.P.	min.	lbs.	acres.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
(a) Cultivating—														
8-2-39	200	1,130	4·09	8·4	15·0	....	7·85	82·75	2·95	10·54	12·0	0·428	0·145	
9-2-39	247	1,240	4·13	9·31	8·0	5·0	9·76	111·0	2·9	11·37	19·75	0·515	0·219	
(b) Max. Load—														
8-2-39 ...	Max. load 1,625 lbs. at 4·15 ft./sec. 12·25 d.b.h.p.							Max. Pull 1,800 lbs. at 3·5 ft./sec. 11·4 d.b.h.p.						
(2) HERBERT.														
(a) Cultivating—														
20-2-39	310	1,355	4·1	10·1	12·0	....	12·2	139·0	2·67	11·40	10·5	0·2018	0·0755	
21-2-39	305	1,260	4·125	9·45	12·0	....	12·1	127·0	2·64	10·5	12·25	0·255	0·0965	
(b) Max. Load—														
20-2-39	Max. load 1,700 lbs. at 4·06 ft./sec. = 12·53 d.b.h.p.							Max. Pull 1,850 lbs. at 3·0 ft./sec. = 9·81 d.b.h.p. Stalling load = 1,960 lbs.						

SERIES D.—LOW COMPRESSION AND STEEL WHEELS.

Pistons: Standard Case Compression Ratio 3·8 : 1.
Ignition Advance: 45° of engine crankshaft.

Wheels: Standard Case fitted with spade lugs.
Plugs: K.L.G. PKA 3.

Date.	Time of Working.	Average Load.	Average Speed.	Average Drawbar.	Time on Petrol.	Petrol Used.	Area Worked.	Fuel Used.			Water Used.			Remarks.
								Total.	Per d.b.h.p. hr.	Per Acre.	Total.	Per d.b.h.p. hr.	Per lb. Fuel.	
	min.	lbs.	ft./sec.	h.p.	min.	lbs.	acres.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
(1) POWELL PLANT.														
(a) Cultivating— 6-2-39	134	600	4·14	4·51	13	8	5·32	79	7·83	14·85	16·75	1·662	0·212	
(b) Maximum Load— 7-2-39	75	Maximum Load 784 lbs. at 4·15 ft./sec. = 5·91 d.b.h.p.						Stalling Load = 900 lbs.						
(2) HERBERT PLANT.														
(a) Cultivating— 22-2-39	65	615	4·6	5·15	6	.....	1·19	Not taken.			Not taken.			
(b) Maximum Load— 22-2-39	....	Maximum Load 616 lbs. at 5·03 ft./sec. = 5·63 d.b.h.p.						Stalling Load = 728 lbs.						

GROUP II.

SERIES A—POWER AND CONSUMPTION TESTS USING KEROSENE.

Standard Pistons and Rubber Tyres.

Pistons: Stand Case compression ratio 3·8 : 1.
Fuel: Cross Power Kerosene.

Ignition Advance: 15° of engine crankshaft.
Tyres: Barnet Glass 4-ply, 11·25 x 24.

(a) Scarifying. (b) Maximum Load.

Date.	Time of Working.	Average Load.	Average Speed.	Average Drawbar.	Time on Petrol.	Petrol Used.	Area Worked.	Fuel Used			
								Total.		Per d.b.h.p. hr.	Per Acre.
	min.	lbs.	ft./sec.	h.p.	min.	lbs.	acres.	lbs.	gals.	lbs.	lbs.
(a)—											
2-3-39	183	1,530	4·1	11·4	9	4·25	7·21	55·25	....	1·5	7·25
3-3-39	405	1,655	4·095	12·3	23	6·5	15·92	127·5	....	1·525	7·98
6-3-39	472	1,558	3·905	11·3	11	....	17·7	147·5	....	1·66	8·34
7-3-39	219	1,420	3·87	10·0	12	....	7·78	60·5	....	1·657	7·77
(b)—											
4-3-39	Maximum Load 2,690 lbs. at 4·04 ft./sec., = 19 75 d.b.h.p. Stalling Load = 3,250 lbs.										

SERIES B—STANDARD PISTONS AND STEEL WHEELS.

Pistons: Standard Case. Cast Iron Compression ratio, 3·8 : 1.
Fuel: Cross Power Kerosene.

Ignition Advance: 15° of engine crankshaft.
Wheels: Standard Case fitted with spade lugs.
(a) Scarifying. (b) Maximum Load.

Date.	Time of Working.	Average Load.	Average Speed.	Average Draw-bar.	Time on Petrol.	Petrol Used.		Area Worked.	Total.		Per d.b.h.p. hr.	Per acre.	Remarks.
(a)—	min.	lbs.	ft./sec.	h.p.	min.	lbs.	gals.	acres.	lbs.	gals.	lbs.	lbs.	
27-2-39 ...	314	1,475	4·09	10·95	12	5·5	....	12·48	109·75	....	1·915	8·82	Lugs bedding well down.
28-2-39 ..	373	1,330	4·21	10·18	10	6·5	..	15·1	111·5	..	1·765	7·38	Wheel rims riding ¼in. off ground on lugs
1-3-39	308	1,135	4·20	8·67	14	....	....	12·43	96·0	....	2·155	7·7	
(b)—													
1-3-39	Maximum Load 1,790 lbs. at 4·25 ft./sec. = 13·85 d.b.h.p. Stalling Load = 1,980 lbs.												

GROUP III.

SERIES A.—POWER AND CONSUMPTION TESTS AT THE BELT DRIVE.

Pistons: Cast Iron. Compression ratio 7·8 : 1.

Ignition Advance: 20° of engine crankshaft.

(a) Powell Gas Plant using Jarrah Fuel.
(b) Powell Gas Plant using Whitegum Fuel.
(c) Herbert Gas Plant using Whitegum Fuel

Date.	Time of Working.	Engine Speed	Brake Horse Power.	Cooling Water Outlet Temp.	Gas. Temp. at Inlet Manifold.	Engine Suction at Inlet Manifold in Water.	Fuel Used.	Water Used.	Fuel per B.H.P. hr.	Water per B.H.P. hr.	Maximum Power Output.
A.—HIGH COMPRESSION PISTONS AND GAS.											
	min.	r.p.m.	lbs.	°C.	°C.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
(a) 20-5-38	175	990·5	17·9	77·5	45	13·0	75·5	20·75	1·445	0·397	19·5
(b) 26-5-38	158	1,000·0	19·55	78·0	43	12·12	69·0	9·8	1·34	0·19	21·1
(c) 30-6-38	165	1,000·0	17·6	77·0	51	19·3	67·25	8·5	1·39	0·1755	18·9
B. STANDARD PISTONS AND KEROSENE FUEL.											
29-5-38	175	1,000·0	23·5	98·0	Not taken.	Not taken.	27·1	....	0·93	....	24·18

LUBRICATION.

Samples of the lubricating oil were taken from the crankcase at regular intervals and were analysed by Messrs. D. Dodd and E. Jarvis at the University of Western Australia. The samples were taken after the engine had been working for at least an hour and usually with the engine running in order to obtain a representative sample.

Methods of Analysis.

(1) Specific gravity obtained by hydrometer at standard temperature.

(2) Viscosity by means of an Ostwald Tube in a bath at 130° F.

(3) Acidity.

(a) Titration mixture—To 25 mls. of alcohol were added 25 mls. benzol and 2 mls. of 2 per cent. alkali blue solution (alcoholic solution), then neutralised to a reddish tinge with NaOH solution.

(b) 50 mls. of the titration mixture were added to 10 mls. of oil and titrated against $\frac{N}{10}$ NaOH solution.

(4) Solid Content.

To 10 mls. of oil was added sufficient petroleum ether to extract the oil, then the minimum was centrifuged to separate the solids. The clear supernatant liquid was then poured off and the residue washed free from the oil by successive additions of petroleum ether followed by centrifuging and decantation. Subtracting the weight (A) of the clean centrifuge tube from the weight (B) of the tube and residue (after drying at 110° C.), the weight of total solids was obtained.

Washing the residue with benzol removed the asphaltenes (after repeated centrifuging and decantation). Subtracting the weight (C) of the dried tube and residue after this operation from the weight (B), the weight of asphaltenes was obtained.

The residue was then transferred to a weighed crucible, ignited, cooled and weighed. The loss of weight in this last operation represented the carbon content. The final residual was the ash.

To express the results obtained as percentages, the volume taken was multiplied by the specific gravity to give the weight of oil taken.

The results have been tabulated in four tables:—

(I) Using Powell Producer Plant.

(II) Using Herbert "Pioneer" Producer Plant.

(III) Using Simplex Producer Plant.

(IV) Using Kerosene Fuel.

Note.—In extracting the oil with petroleum ether, the supernatant liquid was dark in colour, indicating that the so-called tarry content of the oil was dissolved and not included in the total solid content.

TABLE I.

Time of Use. (hrs.)	Specific Gravity 28°C.	Viscosity. Ostwald Time at 130°F.	Acidity. (Concentration).	Percentage of—			
				Total Solids.	Asphaltenes.	Mineral. (ash)	Carbon.
New Oil	0·882	198	0·0	0·0	0·0	0·0	0·0
10	0·880	197	0·002(N)	0·08	0·01	0·02	0·04
20	Insufficient sample	192·5	0·002	0·09	0·014	0·03	0·04
30	0·880	200	0·0024	0·07	0·015	0·035	0·02
40	0·881	189	0·0040	0·33	0·01	0·27	0·05
50	0·885	199	0·0092	0·37	0·01	0·30	0·07
60	0·888	223	0·016	0·49	0·02	0·34	0·12
80	0·892	262	0·031	0·4	0·03	0·25	0·15
120	0·894	280	0·044	0·5	0·04	0·4	0·1
147½	0·894	281	0·043	0·6	0·05	0·4	0·13
170	0·897	306	0·033	0·8	0·07	0·5	0·25
210	0·900	313	0·031	0·8	0·045	0·49	0·2

TABLE II.

Time of Use. (hrs.)	Specific Gravity 28°C.	Viscosity. Ostwald Time at 135°F.	Acidity (Concentration).	Total Solids.	Asphaltenes.	Mineral. (ash)	Carbon.
New Oil.	0·882	139	0·0	0·0	0·0	0·0	0·0
25	0·893	167	0·0104	1·78	0·16	0·51	1·12
45	0·906	195	0·0144	3·22	0·42	0·92	1·89
60	0·908	199	0·0112	3·0	0·34	0·87	1·78
84	0·913	210	0·0104	3·53	0·43	0·99	2·12

TABLE III.

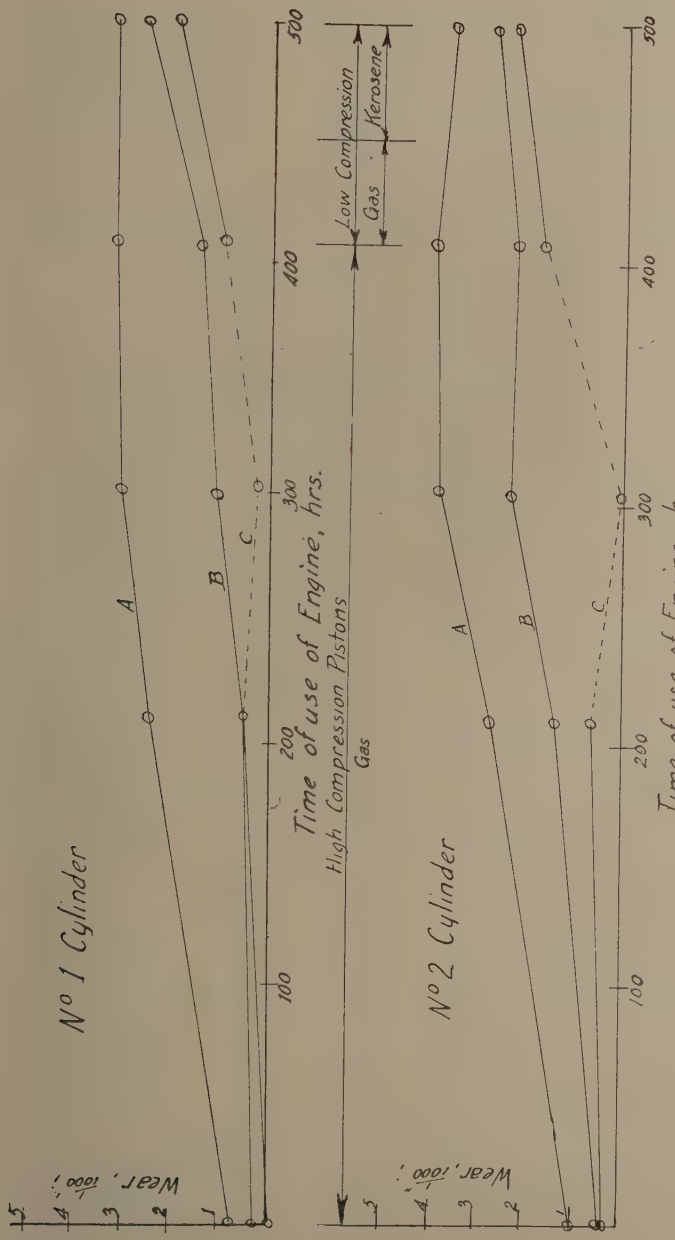
20	0·884	139	0·0100	0·42	0·12	0·15	0·16
40	0·889	156	0·0104	1·29	0·21	0·44	0·64
60	0·905	170	0·0060	3·08	0·13	1·17	1·78
80	0·910	168	0·0060	3·66	0·10	1·48	2·08
100	0·912	190	0·0096	5·69	0·88	1·69	3·13

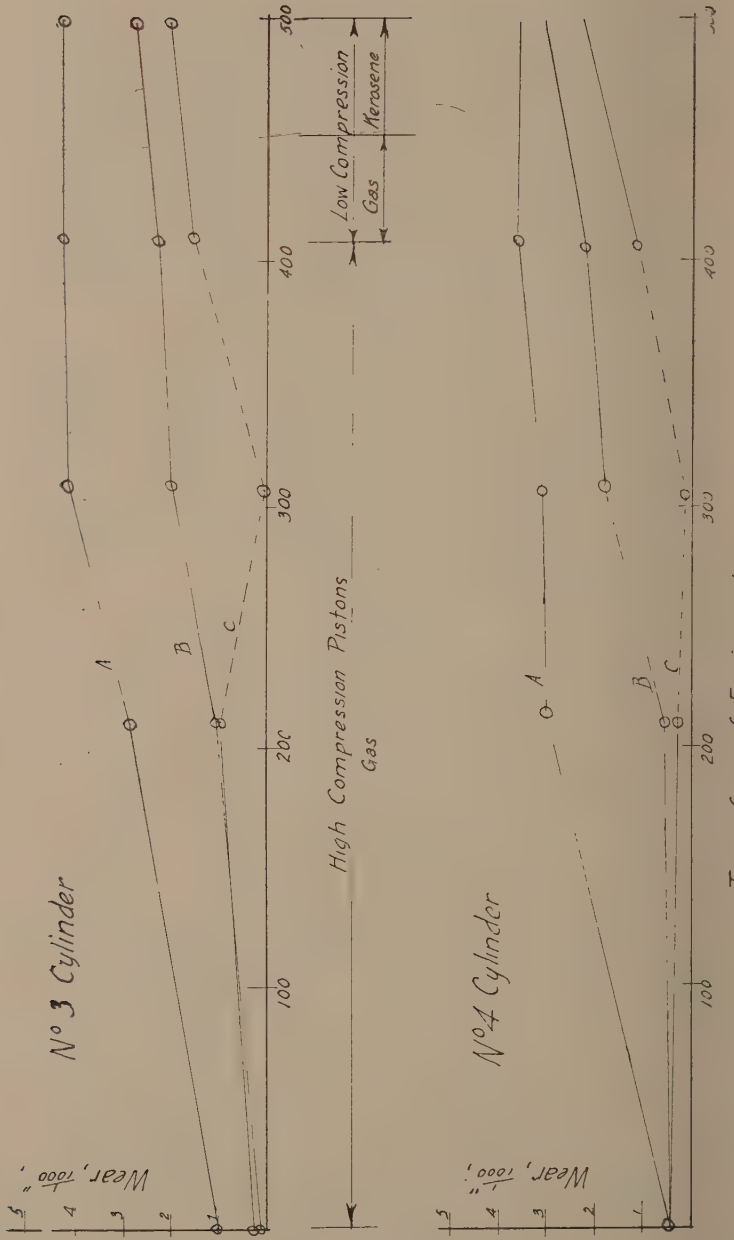
TABLE IV.

10	0·881	82	0·006	0·156	0·02	0·088	0·046
20	0·880	86	0·006	0·154	0·01	0·100	0·044
30	0·880	76	0·002	0·172	0·03	0·098	0·044
45	0·878	60	0·005	0·192	0·03	0·120	0·042

The generally accepted quality of an oil that governs its ability to lubricate two surfaces in sliding contact is its viscosity. The higher the viscosity the better the lubricating qualities but also the greater resistance or drag of the oil. The reason why the oil from a kerosene engine has to be changed frequently is that the dilution of the lubricating oil by the unburnt fuel lowers its viscosity to such an extent that it becomes a poor lubricant. This dilution is entirely absent when gas is used as fuel and the tendency is for the viscosity to increase as the lighter portions of the oil are distilled off or burnt. For this reason, some other factor is to be sought to limit the time of use of the lubricating oil in a gas engine. The most generally accepted limit is when the solid content of the oil becomes sufficiently great to cause wear due to the abrasive action of the particles suspended in the oil.

The results of these analyses show how impossible it is to set down a time for the use of lubricating oil in an engine burning producer gas. Taking a solid content of 1 per cent. as a limiting value, it can be seen that in the first group, the oil was in good condition after 210 hours while in the second group it should have been changed after 20 hours.


Wear, 1000"
1
2
3
4
5
A
B
C
100
200
300
400
500
Time of use of Engine, hrs.
High Compression Pistons
Gas
Low Compression
Gas
Kerosene
No 1 Cylinder
No 2 Cylinder


Wear, 1/1000"
No 3 Cylinder
A
B
C
100
200
300
400
500
High Compression Pistons
Gas
Low Compression
Kerosene
Gas
No 4 Cylinder
Time of use of Engine, hrs.

CYLINDER WEAR.

The cylinder barrel was measured with an Ames cylinder barrel gauge at the commencement of the series of tests, and after each type of producer plant had been tested and again after the engine had been run using kerosene as fuel.

The barrel was measured in three positions: At the bottom of the stroke; at the centre; at the top of the barrel. In each of these positions, the diameter was measured in four directions and the average taken as the mean diameter.

The results have been set out in the form of graphs, each cylinder being separated for the sake of clarity. The graph has as ordinates the diameter of the barrel expressed in 1/1000 parts of an inch above the nominal bore (4.125in.) and abscissae the number of hours working.

Remarks.

The readings taken after 306 hours were taken with the pistons out of the cylinder so that the reading at the bottom of the barrel is lower than it would have been if it had been taken at the same point as the others.

In cylinders Nos. 2 and 4 after the period of use with the low pressure pistons, the diameter at the top of the cylinder appears to have decreased. This could be accounted for by the fact that the piston rings of the low compression pistons do not wipe the top of the barrel and there was probably a film of carbon which could account for the errors of 0.4 and 0.2 1/1000 parts of an inch.

With the results presented in this form, the rate of wear with the relative equipments can be compared with ease. The irregularity of the results can only be explained by the fact that the periods were so short that the errors of measurement were almost as great as the actual wear.

Taking these results in conjunction with the results of the oil analysis, it tends to show that there is little relation between the rate of wear and the total solid content of the oil. For instance, the tests with the Powell plant show that the maximum solid content of the oil is 0.8 per cent., while for the Simplex plant it is 5.69 per cent. Without attempting to average the rates of wear in the four cylinders, it can be seen that throughout, the rate of wear with the Simplex plant is considerably slower than with the Powell plant.

In spite of the fact that the oil in the Powell plant was used for 210 hours, the rate of wear over the whole period does not vary considerably from that obtained by using kerosene fuel and changing the oil after 50 hours.

In light of such results of tests, it appears that the users of gas engines require some method of determining the lubricating qualities of an oil other than those that are in use at present.

ENGINE CONDITION AFTER EACH TEST.

The cylinder head was removed from the engine after the period of test of each plant and inspected. After the inspection, the combustion chamber was thoroughly cleaned and the valves reground preparatory to the next test.

The observations made on the cylinder head condition have been compiled in a brief form under the heading of the various component parts for the sake of comparison.

The subdivisions representing the condition after the period of test with—

(a) Powell Producer Plant .. .. 210 hours.
(b) Herbert Producer Plant .. .. 84 hours.
(c) Simplex Producer Plant .. .. 112 hours.
(d) Kerosene Fuel .. .. 45 hours.

(I.)—*Combustion Chamber.*

(a) Slight deposit of carbon on spark plug side of head cylinder walls coated with oil carbon above limit of movement of upper ring.

(b) Generally medimum carbon deposit heaviest in No. 1 cylinder least in No. 4. In each cylinder the heaviest deposit was on spark plug side of the head.

(c) Heavy oily carbon deposit piston crown having deposit 1/32in. thick —around the exhaust valves the scale showed white.

(d) Cylinder walls and head showed very hard deposit that tended to flake off. Average thickness 1 32in. thickest around the inlet valve reducing to a film near the exhaust valve.

(II.)—*Valves and Seats.*

(a) Inlet valve seats good. Manifold side of valve head covered with oily carbon which could be wiped off. Exhaust valve seats pitted; valve stems showed rusty white film which did not show signs of building up.

(b) Inlet valve seats good; manifold side of valve head had only a film of carbon. Exhaust valve seats pitted; stems showed rusty white film that could be wiped off.

(c) Inlet valve seats good; manifold side of valve head covered with soft dry carbon. Exhaust valve seats pitted; stems showed rusty white deposit.

(d) Inlet valve seats good; no deposit on manifold side of valve head. Exhaust valve seats pitted; valve heads showed rusty film.

(III.)—*Inlet Manifold.*

(a) Dry smeared with lamp black.
(b) Dry smeared with lamp black.
(c) Oily coated with fine carbon deposit.
(d) Clean.

(IV.)—*The Exhaust Manifold.*

Showed clean with (a), (b) and (c) having a white film. With (d), there was a black film.

(V.)—*Spark Plugs.*

(a) Clean porcelain; rusty coloured points burned.
(b) Clean porcelain; rusty coloured points burned.
(c) Black porcelain covered with fine carbon; points burned.
(d) Black porcelain covered with fine carbon; points fair condition.

Remarks.

The condition of the combustion chamber in I. (b) was probably due to the condition of the engine big-end bearings which were slack. During the overhaul at the beginning of which this inspection was made, these were tightened, one

shim being taken out of each bearing. As the oil pump is situated at the same end of the engine as No. 1 cylinder, any slackness in the big-end would tend to cause No. 1 cylinder to obtain more than sufficient oil.

The condition of the exhaust valves and seats after the use of gas showed that the effect of the water in the products of combustion was to cause corrosion of the valve stems and pitting. The latter however had not reached serious proportions after 200 hours work, but it would have been inadvisable to work for longer without paying some attention to the valves.

COSTS.

The cost of working the tractor with which the tests were made was taken as far as possible from the observations made in the field. In seeking a method of presenting the costs in a method that admits fewest assumptions, the basis of draw-bar horsepower hours was adopted. This method permits the complete separation of the use of the tractor from the work it is doing. In order that these costs may be reduced to an average basis, observations were made on the drawbar horsepower hours required to cover one acre by various processes when the work was well done under average conditions. These figures are given at the end of the table of costs.

In arriving at the capital costs, the prices taken for the tractor wheels, gas plants, etc., were those ruling at the time of the tests. The prices of the various makes of gas plant vary, so the figure taken was that of a medium priced plant.

The costs for kerosene were based on the tractor working at its rated output. As the tractor was not rated for use with rubber tyres, an assumed rating was taken which allows the engine to run at its rated engine output with the same power loss between the belt pulley and the drawbar as occurs at maximum loads. With gas as fuel, there is no rated output so that the figures taken as possible working loads, are those that were maintained and appear as averages over a day's working. These are of necessity lower than the maximum.

The fuel consumption for gas varies with the make of plant. In order not to complicate the issue by giving the working costs with each plant fitted, a general value was taken which with some plants can be consistently bettered while with others it represents a fair average value.

The usual method of presenting working costs of a tractor is to assume a certain number of hours' working during the year, and divide up the costs on a time basis. In order that these results may be conveniently compared with others, a table has been made out for the working costs for 120 days work at 10 hours a day at the rated output of the tractor. Another, and it is hoped, a more useful table is drawn up assuming the same amount of work to be done by the tractor with the various equipments. Such a table gives the true comparison of cost of working a tractor under similar conditions when a definite amount of work has to be done.

To facilitate comparison the costs have been put in table form with the items noted as pounds per annum, and then having been totalled, transferred to pence per draw-bar horsepower hour. The table has been made into columns under headings as follows:—

(a) Kerosene fuel. Rubber tyres rated output 16 h.p.

(a') Kerosene fuel. Rubber tyres rated output 12 h.p.

(b) Kerosene fuel. Steel wheels rated output 12 h.p.

(c) Producer gas fuel. Rubber tyres, high compression pistons, oversize cylinder sleeves. Rated output 16 h.p.

(d) Producer gas fuel. Rubber tyres. High compression pistons. Rated output 13 h.p.

(e) Producer gas fuel. Rubber tyres. Low compression pistons. Rated output 9 h.p.

(f) Producer gas fuel. Steel wheels. High compression pistons. Oversized cylinder sleeves. Rated output 12 h.p.

(g) Producer gas fuel. Steel wheels. High compression pistons. Rated output 8. h.p.

(h) Producer gas fuel. Steel wheels. Low compression pistons. Rated output 4 h.p.

Basis for Estimating Costs.

Cost of Tractor: Reconditioned fitted with steel wheels, £230. Reconditioned fitted with rubber tyres, £290.

Cost of producer plant, £90.

Cost of high compression pistons, £8.

Cost of oversized sleeves with H.C. pistons, £15.

Interest taken as 6 per cent. on half the capital cost.

Depreciation: The useful life of the rebuilt tractor being taken as five years. The life of the gas plant being taken as that of the tractor.

Repairs: 40 per cent. of the capital cost divided evenly over the life of the tractor.

Labour: 14.5 pence per hour.

Kerosene: 1s. 3d. per gallon.

Petrol: 2s. per gallon.

Lubricating Oil: 5s. 6d. per gallon.

Charcoal: £2 10s. per ton.

TABLE I.

1,200 working hours per annum.

Fuel	Kerosene.			Gas.					
Wheels	Rubber.		Steel.	Rubber.			Steel.		
Pistons	L.C.		L.C.	H.C. Pistons.		L.C. Pistons.	H.C. Pistons.		L.C. Pistons.
Bore	Normal.		Normal.	Oversize.	Normal Bore.	Normal Bore.	Oversize.	Normal Bore.	Normal Bore.
Item.	a.	a'.	b.	c.	d.	e.	f.	g.	h.
Overhead	89·9	89·9	71·3	122·4	120·28	117·8	103·85	101·95	99·2
Labour	72·5	72·5	72·5	72·5	72·5	72·5	72·5	72·5	72·5
Fuel	204·0	183·0	204·0	60·6	44·8	44·8	60·6	44·8	44·8
Petrol	10·5	10·5	10·5	9·18	9·18	9·18	9·18	9·18	9·18
Lubricating Oil	26·4	26·4	26·4	8·8	8·8	8·8	8·8	8·8	8·8
Total £ p.a.	403·3	382·3	384·7	273·48	255·56	253·08	254·93	237·23	233·48
Work done d.b.h.p. hr.	19,200	14,400	14,400	19,200	15,600	10,800	14,400	9,600	4,800
Cost: Pence d.b.h.p. hr.	5·04	6·37	6·41	3·41	3·93	5·63	4·25	5·94	11·68

TABLE II.

12,000 d.b.h.p. hours per annum.

Item.	a.	a'.	b.	c.	d.	e.	f.	g.	h.
Overhead	89·9	89·9	71·3	122·4	120·28	117·8	103·85	101·95	99·2
Labour	45·3	60·5	60·5	45·3	55·8	72·5	60·5	90·6	182·2
Fuel	132·0	119·0	166·5	34·6	34·6	42·0	75·0	75·0	105·0
Petrol	6·56	8·75	8·75	5·73	7·06	10·2	7·65	11·5	23·0
Lubricating Oil	16·5	22·0	22·0	5·51	6·76	8·8	7·35	10·98	22·0
Total £ p.a.	290·26	300·15	329·05	213·54	224·50	251·3	254·35	292·03	431·4
Cost: Pence d.b.h.p. hr.	5·82	6·0	6·58	4·26	4·49	5·03	5·08	5·83	8·61

TABLE III.

Work per Acre of Various Processes under Conditions of Test.

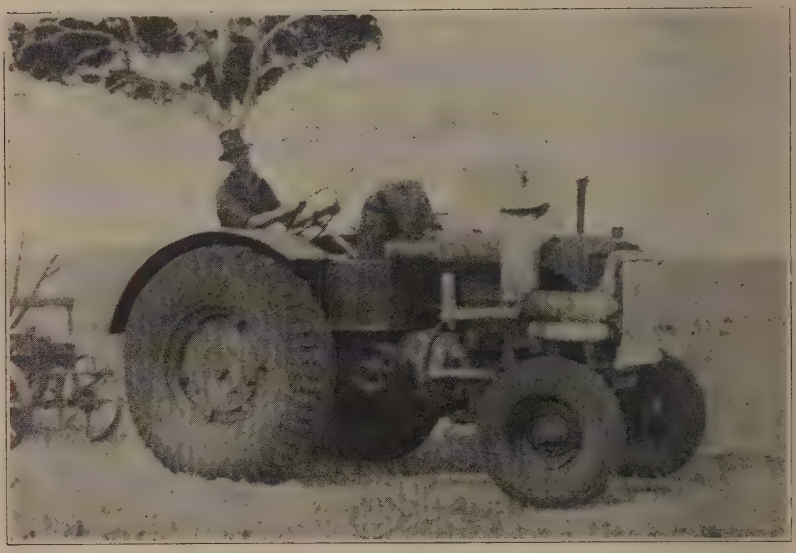
Ploughing (mouldboard) 6in. deep	10·6	d.b.h.p. hrs.	per acre.
Scarifying 6in. deep	4·94	do.	do.
Cultivating 3in.–4in. deep	3·5	do.	do.
Harvesting (Crop, 4 bags per acre)	2·98	do.	do.
Binding	1·98	do.	do.

Column a' has been included as it serves to show the working costs of the tractor if the same implements are used after a tractor has been fitted with rubber tyres as when fitted with steel wheels.

The position illustrated by these figures is then that, if a farmer is using a tractor burning kerosene and fitted with steel wheels, by making an outlay of £80 to fit the plant with rubber tyres, he can cut his costs by £28.9 per annum. If he now buys a complete set of implements, he can cut his costs by a further £10 per annum. However without buying a new set of implements but fitting a gas producer with high compression pistons he can cut his costs by a further £75.65 per annum, so that at the end of the year, the saving due to reduction in working costs is £104.55 with only an outlay of £178 which is earning interest at 7 per cent.

With an outlay of £100 it is possible by using a gas plant with high compression pistons and oversize barrel, yet with steel wheels, to reduce the working costs by £74.7 per annum.

For the farmer who is already working his tractor on kerosene and using rubber tyres, the outlay of £100 that covers the cost of high compression pistons and oversize sleeves as well as the gas plant, enables him to reduce the working costs by £76.72.



Block 11.

The Allis-Chalmers "LL" Tractor.

Block 12.

"ALLIS-CHALMERS" TRACTOR TESTS.

Name and Model of Tractor: Allis-Chalmers "U."

Manufacturer: Allis-Chalmers Manufacturing Company, Milwaukee, U.S.A.

Manufacturer's rating: Kerosene fuel: Engine 31 h.p. Drawbar: Steel wheels 23. Rubber wheels not rated. Gas fuel not rated.

Brief Specifications: Motor own make. Serial No. 17354. 4-cylinder vertical; perpendicular head; mounted crankshaft lengthwise. Bore and stroke 4½in. x 5in.; rated engine speed 1,200 r.p.m., fitted with special pistons giving compression ratio 6.5:1. Ignition: Scintilla-Bendix magneto.

Gas Plant: Herbert "Pioneer." Updraught welded mild steel double shell; drip water feed, manual control; scrubbers, one dry one followed by one oil scrubber and dryer. Cooler multiple tube type situated in front of engine radiator.

Chassis: 4-wheel type. Serial No. U15097. Two driving wheels. Enclosed gear drive.

Advertised speeds, miles per hour: First = 2.33, Second = 3.33, Third = 5.0, Fourth = 11.75, Reverse = 2.67.

Rubber-drive wheel tyres 12.75 x 28 inches. Air pressure 16 lbs. Water filled 360 lbs. tyre. Front tyres 6.00 x 16; air pressure 24 lbs.

Weight of plant: Weight of tractor with operator, 5,476 lbs.; weight of producer plant, 336 lbs.

Fuel: White gum charcoal ex Chidlow, Western Australia. Retort burned.

Lubricating oil: Shell motor oil S.A.E. 40. 3.73 gals. in the engine; oil drained at end of test. Total time of test, 69.5 hours.

Repairs and adjustments: The spark setting was advanced 10° of the engine crankshaft from the normal.

Remarks: The tests were carried out under field conditions; where the load was not constant, the results are based on averages. The maximum load test was based on maximum loads with the load and speed checked over half minute intervals. Maximum observed draw-bar horsepower was 26.5.

The tractor was worked at its third gear speed as the dynamometer was not designed to transmit loads that could be obtained at lower speeds.

The method of observing the speed and load was similar to that used in the tests on the "Case" tractor.

Tests carried out were:—

(a) Scarifying with 16 tyne scarifier. Depth of cut 6-8in.
(b) Cultivating or discing with 14 disc sundercut plough. Depth of furrow 5-7in.
(c) Maximum load tests.

Remarks.—The tractor supplied was fitted with sleeves having 4½in. bore which is standard for all similar tractors supplied in Western Australia. The tractor tested for the Nebraska tests however was fitted with 4⅜in. bore.

Remarks.—The speed of the tractor when using gas is appreciably lower than the advertised speed for kerosene fuel. This drop in speed is noticed as soon as the load becomes more than half the maximum that can be taken. This drop of speed may be overcome by advancing the magneto timing, but the maximum variation that could be made without interfering with the gear timing was used with very little effect. In order to obtain the maximum power output, the governor was set full open with the heavy load applied. With the governor set to limit the engine speed to 1,200 r.p.m. the maximum horsepower output at the drawbar was 22.4.

"ALLIS-CHALMERS" TRACTOR TESTS.

Date.	Time of Working.	Average Load.	Average Speed.	Average Draw-bar.	Time on Petrol.	Petrol Used.		Fuel Used.			Water Used.			Remarks.
								Total.	Per d.b.h.p. hr.	Per acre.	Total.	Per d.b.h.p. hr.	Worked.	
	min.	lbs.	ft./sec.	h.p.	min.	lbs.	gals.	lbs.	lbs.	lbs.	lbs.	lbs.	acres.	
(a)—														
18–10–38	170	1,800	6·7	21·9	20	6·0	....	177	Not checked		....	....	....	
19–10–38	139	1,460	7·3	19·45	20	5·75	....	64	"	"	....	....	....	
20–10–38	366	1,435	6·28	16·4	6	....	....	137	1·37	12·77	Not checked		10·72	Air leak in gas line stopped.
21–10–38	195	1,570	5·4	15·5	8	....	....	98·5	1·695	17·01	23	0·457	5·79	
28–10–38	354	1,500	6·41	17·5	12	5·5	....	272	2·65	22·2	23	0·204	12·22	
29–10–38	507	1,540	5·5	15·4	11	3·25	....	218	1·677	17·65	Not checked		12·33	Ploughing 8 furrow, mouldboard.
(b)—														
19–12–38	289	1,270	6·67	15·4	10	Not checked		297	....	....	34	....	17·2	
20–12–38	315	1,300	6·6	15·6	23	"	"	138	2·08	8·89	10	0·213	18·75	
21–12–38	260	1,290	6·7	15·5	18	"	"	120	....	....	31	....	15·5	
22–12–38	300	940	7·25	12·4	14	"	"	62	....	....	—17	....	17·85	Water removed from tank at end of period.
3–1–39	265	1,300	6·6	15·6	12	"	"	195	....	....	72	....	15·8	
4–1–39	363	1,320	6·65	15·98	16	"	"	177	1·72	7·53	....	0·221	21·65	
5–1–39	265	1,270	6·7	15·49	11	"	"	126	....	....	21	....	15·8	
6–1–39	380	1,290	6·4	15·0	8	"	"	73	....	....	—22	....	22·6	
(c)—														
20–10–38	Maximum Load 2,580 lbs. at 5·65 ft./sec. = 26·5 h.p.							Maximum Pull 2,700 lbs. at 4·5 ft./sec. = 22·1 h.p.						Stalling Load = 2,800 lbs.

Engine Condition after 69.5 hours' Work.

(1) *Combustion Chamber.*

Generally clean. A wipe with a rag left bright metal showing. A ring of carbon deposit was formed around the outer edge of the top of the piston which diminished to nothing at the centre of the piston. At the edge, this ring was approximately 1/32 of an inch thick. The deposit showed a tendency to lift away.

(2) *Valves.*

Valve seats were slightly pitted. The exhaust valves generally were pitted while the inlet valves showed marks that could be removed by a rub with grinding paste. The manifold side of the inlet valves was covered with a light coat of lamp black that could be wiped off with a rag. The exhaust valves had a harder deposit, which was a rusty white colour, part of which could be rubbed off with cloth but the majority of which required scraping to remove it.

(3) *Cylinder Wear.*

The measurements of the cylinder barrel were not taken before the tests were made so that no absolute record of the wear is available. The engine was almost new before the tests having been run enough to run it in. Measurements were made after the tests with an Ames cylinder barrel gauge with the instrument set at zero for the nominal base of 4½in.

The readings were taken in two directions:—

(a) Parallel to the crankshaft.

(b) At right angles to the crankshaft.

The gauge was placed at the bottom of the barrel and moved up the cylinder,—the first reading being that at the bottom of the cylinder and the second, the maximum divergence from it, which usually occurred ¾ of an inch from the top. All readings are in 1/1000 parts of an inch.

	a	b
No. 1 cylinder:	—1½ to —1	—1 to 0
No. 2 cylinder:	—2½ to —2½	—1 to 1
No. 3 cylinder:	—2½ to —2	—½ to 0
No. 4 cylinder:	—2 to —1½	—2 to 0

Working Costs using Allis-Chalmers Tractor with Producer Gas as Fuel.

Cost of tractor new fitted with Herbert Gas Plant: £575.

Cost per annum assuming 24,000 d.b.h.p. hours per annum:

Overhead:	
Interest 6% on half capital	17.25
Depreciation for 8 years life	71.87
Repairs and maintenance 40% of capital over life	28.73
	£117.85
Labour: 14.5 pence/hr. for 1,200 hours	72.5
Fuel: 1.9 lbs./d.b.h.p.hr. @ 0.3 pence/lb.	57.
Lubricating oil: 3.75 galls. every 150 hours @ 5s. 6d. gallon	7.5
Petrol	8.37
	263.22

Cost per d.b.h.p. hr. = 2.63 pence.

Therefore cost of scarifying to a depth of 6 inches on normal land, using figures previously quoted 2.63 x 4.94 = 13 pence per acre. Similar costs for the

same tractor using kerosene and equipped with rubber tyres can be calculated from the results of the Nebraska Tests.

Overhead Costs:—

	£	£
Interest	14.85	
Depreciation	62	
Maintenance	24.8	
		101.65
Labour 14.5 pence/hr. for 1,200 hours		72.5
Fuel 0.82 lbs./d.b.h.p. hr. @ 1.75 pence/lb.		143.5
Petrol		8.42
Lubricating oil: 3.75 galls. every 50 hours @ 5s. 6d. gall.		24.75
Therefore cost /d.b.h.p. hour 3.5 pence.		£350.82

Cost of scarifying: 17.35 pence/acre.

Time and Labour Entailed in Preparing a Tractor for Work.

Throughout the tests, a check was kept on the time required to prepare the tractor for work. The total time was noted from the time the driver was ready to commence work till the time the tractor was actually drawing the implement for the time required to start work, and if the driver elected to do any draining or other servicing when he stopped work, the time taken was noted from the time the tractor stopped working to the time the driver stopped work.

This check involved including the time taken for all measurement of quantities of fuel, etc., that were made. In order to obtain a time that was free from procedures that were purely for test purposes, the time required for each procedure was noted.

A.—Time involved during the working day in servicing a tractor fitted with a Producer Gas Unit.

(a) *Morning.*—Selecting and weighing sufficient charcoal for 9 hours work	10 min.
Cleaning out and weighing residue in generator	10 min.
Fill generator with fuel and cleaner with oil	5 min.
Weigh and pour into tank sufficient water	5 min.
Top up radiator, starting engine and changing on to gas	6 min.
Greasing tractor	8 min.
Total	44 min.
(b) *During the Day*:	
Morning:	
Fill generator after 2½ hours from bag carried on tractor or implement	4 min.
Stop for lunch allowing tractor to idle	2 min.
Afternoon:	
Refill generator and start	6 min.
Refill generator from bag carried on tractor or implement	4 min.
Stop in evening with engine idling	2 min.
Drain oil from scrubbers	2 min.
Draining and weighing water	4 min.
Total	24 min.

Total time taken in a day—1 hour 8 minutes.

B.—(a) Making no allowances for time of weighing and cleaning generator once a week:

Filling generator and selecting day's supply of fuel	8 min.
Filling cleaner with oil	4 min.
Filling tank and radiator with water	4 min.
Greasing tractor	8 min.
Starting up and changing over	6 min.
	30 min.
(b) During the day as before	24 min.
Total	54 min.

C.—(a) Using kerosene fuel:

Weighing and pouring into tank day's supply of fuel	10 min.
Greasing	8 min.
Starting engine and warming up on petrol	10 min.
Filling up radiator	2 min.
	30 min.
(b) During the day:	
Stopping for lunch, drain kerosene out of carburettor	3 min.
Starting and changing to kerosene	5 min.
Topping up radiator	3 min.
	11 min.
Total	41 min.

The time required to weigh the kerosene was 2 minutes, so that in practice the total time required is 39 minutes. In all the increase of servicing time can be considered to be 25 minutes. This can be materially reduced when an attempt is seriously made, but to allow the work to be done efficiently without undue hurry, the times given which are averaged over a long period and then given to the nearest minute are those that may be reasonably expected.

The servicing time with a producer plant fitted can be materially reduced with two men working. It is possible to work without undue haste and have the tractor working 25 minutes after the men commence work in the morning. Thus if a second man gives assistance for 25 minutes a day, the time can be reduced to that required for servicing a kerosene tractor.

Compared with this under test conditions, one man performed the whole task of preparing the tractor for work in the morning in 26 minutes from the time he commenced work to the time he started the farming operation he had to do. Also the time required to refuel during the day was several times only 2 minutes from the time the tractor stopped to the time it began under load. To keep to this time requires that the engine is not stopped and the only way to refuel without stopping the engine is to be quick.

A further observation that was made throughout the tests was the weight of dust collected in the cleaners each day. For the purpose of power and consumption figures, these observations are useless. The dust so collected is too fine to be of any use and is therefore waste. It is not possible to subtract this from the

fuel used when calculating the consumption figures. From the point of view of design of dry cleaners, however, it is of considerable interest and value. When testing a cleaner, it is very advantageous to know at what speed the dust has to be fed in so that conditions may approach working conditions. Similarly in the design; if the approximate rate of collection of dust is known, the capacity of the collection chamber can be designed so that it will just be full at the time of empyting, thus doing away with unnecessarily cumbersome cleaners.

The figures obtained vary according to the load and in some cases appear to be very irregular. The general value however can be arrived at as follows:—

Powell Plant—0.3 lbs./hr. for light loads extending to 1.3 lbs./hr. for heavy loads.

Herbert "Pioneer" Plant—0.7 lbs./hr. for light loads increasing to 2.0 lbs./hr. for heavy loads.

"Simplex" Plant—0.25 lbs./hr. for light loads increasing to 0.4 lbs./hr. for heavy loads.

The very low rate of dust collection in the "Simplex" is due to the fact that the gas is taken from the generator above the surface of the fuel, with the result that there is a large capacity settling space before the first cleaner, so decreasing the amount of dust taken over with the gas.

With the Herbert "Pioneer" and "Powell" generators, however, the take-off is similarly situated in the fuel bed, and if anything, the larger take-off area of the Herbert should cause less coarse dust to be held in suspension.

Taking the efficiency of the Herbert cleaner as 60 per cent., the rate of dust flow in the gas varies between 1.165 and 3.33 pounds per hour according to the load.

The efficiency of the Powell cleaner is then 39 per cent. at high loads and 25.8 per cent. at low loads.

It was impossible to separate the oil from the dust collected in the oil scrubber sufficiently to estimate the amount of dust collected in it, so that a check on the total solids in suspension in the gas is not possible. However the figure of 60 per cent. efficiency was obtained by a Herbert dry cleaner when tested at the University of Western Australia, under conditions similar to those met with in practice.

THEORETICAL ASPECTS IN THE DESIGN AND USE OF PRODUCER GAS.

Calorific Value of Fuels.—The calorific value of the air-fuel mixture when a petroleum fuel is used which has a calorific value of 20,000 B.Th.U. per lb. is 104.5 B.Th.U. per cubic foot.

In comparison the calorific value of the air fuel mixture when producer gas is used, varies between 65 and 82.2 B.Th.U. per cubic foot, depending on the efficiency of the producer. In a plant that is working with practically no heat loss, and is employing the sensible heat of the gases, leaving the generator to pre-heat the water, it is possible to generate a gas which will give a mixture of calorific value of 82.2 B.Th.U. per cubic foot. In such plants where this ideal condition does not hold and the sensible heat of the gas is wasted in coolers, the maximum calorific value of the mixture is 79.1 B.Th.U. per cubic foot. A more practical figure is that when the total heat losses are 10 per cent., i.e., the generator is working at a 90 per cent. overall efficiency; a condition which has frequently been obtained in practice, the calorific value of the air-fuel mixture is then 77.2 B.Th.U. per cubic foot.

Thus from consideration of the calorific value of the fuels, the maximum power output with gas as fuel is 74 per cent. that of kerosene.

Compression Ratio.—An engine using kerosene tends to develop pinking or detonation when the compression ratio is raised above 4:1. When gas is used as fuel, such a phenomenon does not occur.

In arriving at the maximum compression ratio at which it is possible to operate an engine burning producer gas, the sole limiting fact is the temperature of spontaneous ignition of a mixture of Hydrogen, Carbon Monoxide, Carbon Dioxide, and Nitrogen Gases. K.G. Falk (Journal Amer. Chem. Soc., 1907) obtained the value of 550° C. to 620° C. for such a mixture depending on the exact proportions. These values were obtained by the method of instantaneous compression, a method which has since been proved inaccurate, but which serves to show the limiting compression ratio admirably.

Accepting the lower value of 550° C. for the purpose of general work, it is then possible to calculate the maximum possible compression ratio.

Taking the equation for adiabatic compression $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{8-1}$

and assuming the initial temperature to be 60° F. the limiting compression ratio is 13.5:1. However, with an initial temperature of 170° F., which is the temperature of the cooling water, the maximum compression ratio is reduced to 8.6:1.

The air standard efficiency of an engine using a compression ratio of 8.6:1 is 57.5 per cent. Compared with this, the air standard efficiency of an engine using a compression ratio of 4:1 is 42.5 per cent.

Assuming that an engine works at 50 per cent. of its air standard efficiency, we have then that a gas engine burning a fuel air-mixture of 77.2 B.Th.U. per cubic foot at 28.7 per cent. efficiency delivers 22.1 B.Th.U. per cubic foot of mixture used. A kerosene engine however burns a fuel air-mixture with a calorific value of 104.5 B.Th.U. per cubic foot at an efficiency of 21.25 per cent. and delivers 22.2 B.Th.U. per cubic foot of mixture used. The possible power output of an engine so modified for the use of gas is then 99.6 per cent. of the power output when using kerosene.

In order to obtain full benefit of this, it is necessary to have an engine with the combustion chamber designed to give the greatest possible heat conduction, so that the temperature of the incoming charge before compression is as low as possible. Without good heat conduction, pre-ignition is capable of causing a greater loss of power than can be hoped to be obtained with the increased compression ratio.

Dimensions of the Generator.—In the tests conducted, there was very little variation in the size and design of the generators, the essential difference between the Herbert and the Powell producers being that the former had an effective flame path length of 13½ inches while the latter had a flame path length of 18 inches. The diameters are very nearly the same. In the laboratory tests under steady conditions, the plant with the longer flame path gave a higher maximum power output. While in variable field conditions, the plant with the shorter flame path gave the higher power output. Under all conditions, the fuel consumption of the plant with the shorter flame path was the lesser. These results show that

there is a certain amount of reversal of the action by which carbon monoxide is formed, when a long time of contact is used with the consequent formation of a gas rich in hydrogen and containing carbon dioxide.

It is possible to reap the benefit of this effect in the use of a stationary plant with steady load conditions, but in a mobile unit with variable load conditions such as are met in field work, it is impossible to maintain the fire in a sufficiently stable state to allow the greatest benefit from the use of the exact quantity of water to be obtained.

CONCLUSION.

From the results of the tests which have been presented in this report, it can be seen that the use of a cheap fuel similar to producer gas is a very real method for a farmer to cut his working costs. The results of the power and consumption tests show that the maximum horsepower at the belt is 87.4 per cent. of the kerosene output while the maximum output at the drawbar is 77 per cent. Thus there is a definite loss of power with the engine used. In spite of this loss of power with the present prices of fuel oil, labour and tractor, the working costs show that a tractor equipped with producer gas and high compression pistons can operate at 77 per cent. of the cost per drawbar horsepower of a kerosene tractor equipped with rubber wheels. With the modern tractor the costs are considerably reduced, but the gaseous fuel shows an advantage of 25 per cent. over the kerosene tractor.

The series of tests conducted were designed primarily to obtain definite figures for the use of gas on farms in place of kerosene. The merits and demerits of the use of such a fuel for transport with cars and trucks have not been investigated in this instance. In the average car, the greater proportion of the running costs is made up of the overhead expenses. Compared with this, however, the price of fuel is 2.34 pence per pound for petrol, and 0.3 pence per pound for charcoal. If then the weight of fuel consumed per mile were double that when using petrol, the fuel costs would be divided by four when gas was used. This should more than compensate for the increase in the capital cost.

In calculating the cost of lubricating oil for the tractor, it was assumed that the oil would be used for three times as long when using gas as when using kerosene. This is purely an assumed figure as the engine was operated up to 210 hours or four times the normal period without change of oil, yet no apparent damage was done. For this reason, it is very difficult to give a definite figure for the life of the lubricating oil, but 150 hours is considered sufficiently conservative to enable the engine to give the maximum work with the minimum expense. Such a figure must always be limited with a proviso that the cleaning system be in good condition.

When dealing with the theoretical aspects of the production of producer gas it was shown that with a well designed generator that gave a good quality gas, it was possible by raising the compression ratio of a kerosene engine to obtain almost the same power output as with kerosene without further modifications. To obtain such results, a very cool running engine is required.

In all, the use of a tractor equipped with a producer gas generator for a period of six months under test conditions showed that the plants tested were suitable for use on a farm without further alterations.

Cleanliness in Dairy Routine.

A. L. HAMILTON, Dairy Adviser.

Much has been written on "cleanliness" in the various phases of the production of top grade dairy products, *i.e.*, washing utensils, cleaning separators, milking machines and so on, and it will be readily admitted that this subject is of paramount importance to the dairy farmer who is paid according to grade for his produce.

This article has been written in an endeavour to include the most important sections of all these operations under the heading of "Cleanliness in the Dairy Routine."

Taking the various operations in order of their occurrence, the first point which warrants close attention is:—

Cleanliness of the Cow:

The hair of the coat and on the udder is a fruitful source of bacterial contamination when the cows come in from the paddocks. In the summer bacteria laden dust invariably exists on the hair, and in the winter when the cows are wet with rain or dew the drops of water contain many thousands of bacteria and are a source of contamination by undesirable types when the water is allowed to drop into the milking bucket.

It is recommended that a cloth which has been dampened with a dilute solution of potassium permanganate (Condy's crystals) should be used to wipe over the flanks and udder of the cow immediately prior to milking.

The first squirt of milk from each teat should be discarded for the reason that bacteria find their way into the teat from the exterior and multiply there between milkings.

Methods of Milking:

It is a well-known fact that so-called "wet milking" is definitely a contributing source of the bacteria in milk. A smear of petroleum jelly on the teats should obviate the necessity for wetting the milker's hands with milk and has the effect of keeping the teats in healthy condition.

Cleanliness and health of persons tending the cows, of course, is essential in the production of bacteriologically clean milk.

Cleansing of Separator and Utensils:

In cleansing the separator and dairy utensils three processes are necessary, any one of which is useless unless combined with the other two:—

(a) Washing with lukewarm water to remove the curdy sediment which, if left, will form upon subjection to heat an insoluble substance (milk-stone) which is particularly difficult to remove.

(b) Washing and scrubbing with scalding hot water containing washing soda or other recognised dairy cleanser.

(c) Sterilisation with steam. A simple steaming device for placing over a copper of boiling water is described in Leaflet No. 424 which may be obtained on request.

It may be said here that the growth of organisms from the time of washing and sterilising to the time of the next milking can be very great, and therefore considerable benefit can be derived by a second sterilising of all utensils immediately prior to milking with either steam or chemical sterilisers containing chlorine compounds. Chlorine disinfectants are marketed at present in powder form which is preferable to liquid chlorine disinfectants, as the powder is less likely to deteriorate in storage.

All utensils, after sterilising, should be placed on racks so that the metal surfaces dry out rapidly. Bacteria will multiply in the presence of moisture.

Cleansing the Milking Machine:

Probably the most fruitful source of bacterial contamination of milk on the farm is caused by lack of attention to the proper cleanliness of the milking machine, which is due to lack of knowledge on the part of the dairy farmer as to the most efficacious cleaning method or failure to dismantle the important units in the milk line as explained later.

The following method has given excellent results and is recommended to users of machines (see "Journal of Agriculture of W.A.," September, 1933, pages 385-391, i.e., "The Cleansing of Milking Machines," by M. Cullity, Agricultural Adviser, Dairy Branch):—

(1) Before milking draw cold water through all milk tubes and releaser, so as to prevent adhesion of milk to pipes, rubbers, etc.

(2) Immediately after milking, wash all the dirt off the outside of the teat cups and rubbers, then draw sufficient warm water through to flush out the milk system. When drawing the water through the set farthest from the releaser, insert a ball of horse-hair in the end of the milk pipe so that it will travel through to the releaser with the water. Withdrawing the horse-hair or brush with a cord recontaminates the pipes.

(3) Next draw through each set of teat cups not less than 1 gallon of boiling water to which has been added caustic soda at the rate of 1 to 1½ teaspoonsful per 4 gallons of boiling water. Distribute the solution as evenly as possible through each set of teat cups.

(4) Immediately follow by flushing out the caustic soda solution with 2 gallons of hot or 1 gallon of boiling water for each set of teat cups.

(5) Remove or open the plug or flap from the releaser pipe to allow of free circulation of air.

(6) Next clean the vacuum system in the same manner as the milk system by drawing through first the caustic soda solution and the boiling water which has been circulated through the milk system. Pay particular attention to the cleaning of the pipe connecting the releaser to the vacuum tank by flooding the releaser to cause the water to flow through to the vacuum tank. *This is important.*

(7) The engine can now be stopped. Disconnect the two long rubbers from downpipe and teat cups and hang in a clean dry airy place out of direct sunlight.

(8) Disconnect the releaser, wash, rinse and place in a clean dry sunny place, then disconnect the top or bottom half of the vacuum tank and treat in the same manner. To be successful *these operations*

must be carried out daily. This does not dispense with the necessity of dismantling the machine as often as possible so that all joints and crevices may be examined and treated.

The use of caustic soda in the method herein described does away with the use of brushes or scrapers which score or cut the inside rubber surfaces, so making irregularities which harbour fat and casein, etc., and support subsequent bacterial development, leading to heavy contamination.

It also is necessary to have yards, bails and surroundings in clean condition, in order to minimise contamination with dust, dung, etc. With this in view, compliance with the following conditions taken from the Health Act, 1911-1919, regulations has become necessary:—

(a) The floor of a properly constructed milking shed must be concrete or other impervious material and correctly drained into an open impervious drain at least 20 feet away from the shed.

(b) A milk and cream storage room must be built on approved lines with a concrete floor and properly ceiled and ventilated, also fly-proof, and be at least 10 feet from the milking shed.

(c) Provision must be made for boiling water to be available at the bails immediately adjacent to the washing up facilities in use.

(d) Cow bails and sheds must be lime-washed or painted with other suitable preparation. A 4-foot dado of tar or bituminous paint is recommended as being simple to wash down.

It may be said in conclusion that only a few cases of unsatisfactory milk or cream quality are traceable to any single source of origin, but most cases are due to a culmination of many small and seemingly unimportant foci of bacterial contamination which can only be eliminated by careful attention to detail, as outlined above, in every operation of the dairy routine.

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The Baking Quality of Wheat Fertilised with "Minor Elements" in Western Australia.

L. W. SAMUEL, Cereal Research Officer.

(1) *Introduction*:

The Department of Agriculture of Western Australia conducted a number of experiments on the use of "minor" elements on the growth and yield of wheat during the 1938-39 season. Samples of the grain from two of these experiments have been examined for baking quality by the "wholemeal fermentation time" test (Pelshenke test) and by the Brabender farinograph. Details of these two tests as used in this laboratory for the estimation of baking quality have previously been published. (Samuel, 1938.)

(2) *Materials*:

The wheat samples examined were from the experiments at—

(a) the Wongan Hills Research Station on sand-plain country, described by Teakle & Thomas (1939), and

(b) Wagin, on light lands ranging from gravelly sand-plain to a light sandy loam, described by Stewart & Teakle (1939),

and details of the soils, cultural treatments, field response and yield are given in the publications cited so that only essential details will be repeated in this paper.

(3) *Wongan Hills Research Station*:

Three series of 6 x 6 latin squares were used to explore the effect of fertilising with elements other than phosphorus. The wheat variety Nabawa was sown by hand and the fertilisers applied as complete mixtures to the same rows. Each plot was 48 inches long by 7 rows (49 inches) wide and the grain was harvested from one square yard from the centre of each plot.

(a) Each sample was subjected to the "wholemeal fermentation time" test and the results analysed statistically. The data are summarised in Table 1.

TABLE 1.

The baking quality, as judged by the "wholemeal fermentation time," of Nabawa Wheat fertilised with "minor" elements.

Treatment.	"Wholemeal fermentation time" (average). mins.
Series 1.	
Control—N + P + K	47
Control plus copper sulphate	49
Control plus manganese sulphate ..	47
Control plus borax	49
Control plus zinc sulphate	39
Control plus magnesium sulphate ..	47

Difference necessary for significance (P = 0.05) = ± 3 mins.

TABLE 1—*continued.*

Treatment.	"Wholemeal fermentation time" (average).
Series 2.	mins.
Control—N + P + K	49
Control plus ferrous sulphate	47
Control plus manganese sulphate and copper sulphate	49
Control plus manganese sulphate, copper sulphate and zinc sulphate ..	44
Control plus mixture M	46
Control plus mixture Q	50
Difference necessary for significance (P = 0.05) = ± 3 mins.	
Series 3.	
Control—N + P + K	47
Superphosphate only—2 cwt. per acre ..	52
Superphosphate plus borax	51
Superphosphate plus manganese sulphate	50
Superphosphate plus zinc sulphate ..	42
Superphosphate plus copper sulphate ..	51
Difference necessary for significance (P = 0.05) = ± 3 mins.	

Mixture M contains manganese, copper, zinc, magnesium and ferrous sulphates and borax. Mixture Q contains sodium tungstate, cobalt chloride, antimony chloride, potassium iodide and nickel chloride each at the rate of 5 lbs. per acre.

Fertilisers were applied at the following rates:—Control mixture: Sulphate of ammonia, 1 cwt. per acre; Superphosphate, 2 cwt. per acre; Sulphate of potash, 0.5 cwt. per acre. "Minor" elements: Manganese sulphate, copper sulphate, zinc sulphate, ferrous sulphate and magnesium sulphate—each 20 lbs. per acre. Borax 10 lbs. per acre.

From series 1, none of the "minor" elements has improved the baking quality of the wheat and only the application of zinc sulphate has significantly decreased the baking quality.

From series 2, none of the "minor" elements has improved the baking quality of the wheat and the application of zinc sulphate in combination with other minor elements has decreased the baking quality.

From series 3, the use of nitrogenous and potassic fertilisers in addition to superphosphate has significantly decreased the baking quality of the grain. None of the "minor" elements has improved the baking quality but the use of zinc sulphate has significantly decreased the baking quality.

(b) Since the samples of grain available were too small for each to be milled and farinographed the six samples from each treatment were bulked in two lots of three samples each and each bulk lot milled and farinographed. This resulted in duplicate determinations on each treatment and the averages of these duplicates are shown in Table 2.

TABLE 2.

The baking quality, as judged by the Farinograph, of Nabawa wheat fertilised with "minor" elements.

Treatment.	Farinogram. W.A. %	S.F.	D.W.	D.D.T.
Series 1.				
Control—N + P + K	60.8	5.6	80	1.6
Control plus copper sulphate ..	59.8	5.8	70	1.8
Control plus manganese sulphate ..	59.6	5.8	80	1.5
Control plus borax	59.8	6.1	70	1.6
Control plus zinc sulphate	59.6	5.1	110	1.6
Control plus manganese sulphate ..	59.8	5.8	80	1.6

TABLE 2—*continued.*

Treatment.	Farinogram. W.A. %	S.F.	D.W.	D.D.T.
Series 2.				
Control—N + P + K	59.5	6.6	70	1.8
Control plus ferrous sulphate ..	59.7	7.2	50	1.6
Control plus manganese sulphate and copper sulphate	59.6	6.6	70	1.5
Control plus manganese sulphate, copper sulphate and zinc sulphate ..	60.1	6.3	75	1.5
Control plus mixture M	59.8	6.8	70	1.6
Control plus mixture Q	59.8	6.5	70	1.6
Series 3.				
Control—N + P + K	59.2	6.2	70	1.8
Superphosphate only—2 cwt. per acre	60.2	6.8	60	1.6
Superphosphate plus borax	59.9	6.6	65	1.5
Superphosphate plus manganese sulphate	59.7	6.4	70	1.6
Superphosphate plus zinc sulphate ..	60.7	5.6	90	1.5
Superphosphate plus copper sulphate	59.7	6.8	60	1.6

W.A. is water absorption on 13.5% moisture basis. S.F. is strength figure: the time in minutes from the commencement of mixing until the top of the farinogram falls below the maximum consistency of 500 units. D.W. is dough weakening: the number of consistency units by which the median line of the farinogram has fallen below the maximum consistency of 500 units after 10 minutes mixing. D.D.T. is dough development time: the time in minutes from the commencement of mixing till the farinogram attains maximum width. Rates of application of fertilisers are as noted under Table 1.

The farinogram results cannot be treated statistically so that no accurate estimation of significance can be given but general experience with the farinograph indicates that in Series 1, no "minor" element has affected the water absorption or the dough development time of the flour. The only effect of "minor" elements on strength figure is that the application of zinc sulphate has decreased the strength figure with a consequent increase in dough weakening.

In series 2, no "minor" element or combination of "minor" elements has affected the water absorption or dough development time of the flour. The addition of ferrous sulphate has increased the strength figure with a consequent decrease in the dough weakening.

In series 3, no treatment has materially affected either the water absorption or the dough development time of the flour. The addition of nitrogenous and potassic fertilisers has decreased the strength figure and hence increased the dough weakening as compared with superphosphate alone. The addition of zinc sulphate has considerably decreased the strength figure and increased the dough weakening. These results confirm the findings of the "wholemeal fermentation time" test.

In addition to the effect on the analytical results for baking quality the use of zinc sulphate resulted in a substantial lowering of the commercial qualities of the grain as it caused considerable to very severe shrivelling of the grain and induced a dirty, greyish colour on most of the injured grain.

(4) *Wagin.*

To make qualitative observations on the effects of some "minor" elements on some representative types of light land an exploratory experiment with wheat was carried out using plots of 0.43 acres each in area and 14.3 chains long. Each treatment was in duplicate with the control plot regularly interspersed so that there were eight control plots.

Nabawa wheat was sown on clean fallow in good condition and all plots, except those receiving superphosphate only, received a basal fertiliser dressing at the rate of 1 cwt. of superphosphate and 0.5 cwt. of sulphate of potash per acre. The "minor" elements were mixed with the basal fertiliser and applied by means of a combine drill in the usual way, the drill being frequently checked for rates of sowing.

Harvester samples from each plot were examined and the average results are shown in Table 3.

Table 3.

The baking quality, as judged by the Farinograph and "wholemeal fermentation time," of Nabawa wheat fertilised with "minor" elements.

Treatment.	Farinogram.				Time.
	W.A. %	S.F.	D.W.	D.D.T.	(mins.)
Superphosphate	62.2	6.4	70	1.9	47
Control—Superphosphate plus sulphate of potash	62.6	5.8	75	1.7	46
Control plus manganese	62.8	6.2	65	1.6	44
Control plus iron	62.4	6.4	60	1.6	44
Control plus copper	62.4	5.6	80	1.6	48
Control plus zinc	62.6	6.0	70	1.8	42
Control plus cobalt	62.4	6.5	70	1.8	46
Control plus boron	62.5	5.6	90	1.5	51
Control plus copper, manganese, and zinc	62.6	6.1	70	1.6	46

W.A. is water absorption. S.F. is strength figure. D.W. is dough weakening. D.D.T. is dough development time. Time is "wholemeal fermentation time."
Rates of application of fertilisers:—Superphosphate, 1 cwt. per acre; Sulphate of potash, 0.5 cwt. per acre; Manganese sulphate, ferrous sulphate, copper sulphate, 20 lbs. per acre; Zinc sulphate, borax, 10 lbs. per acre; Cobalt chloride, 1 lb. per acre.

Though no statistical estimate of significance can be given for these results it appears that the addition of zinc sulphate to the basal fertiliser has decreased the "wholemeal fermentation time" and the addition of borax has increased it. No treatment has materially affected the water absorption or dough development time of the flour. The omission of sulphate of potash from the basal fertiliser has increased the strength figure, as has the addition of ferrous sulphate and cobalt chloride. No "minor" element treatment has materially decreased the strength figure.

The indications from the two tests used for baking quality are therefore not consistent and further information is required before definite conclusions can be drawn.

(5) *Summary and conclusions.*

Samples of Nabawa wheat from two experiments on the use of "minor" elements as fertilisers for wheat on light land have been examined for baking quality.

The addition of sulphate of potash, with or without the addition of sulphate of ammonia, decreased the "strength" of the flour obtained.

None of the "minor" elements tested affected materially the water absorption or dough development time of the flour.

As with other agronomic characters, the effect of "minor" elements on "strength" of flour varies with locality, a decrease in "strength" being caused by zinc sulphate fertiliser at the Wongan Hills Research Station but not at Wagin.

It appears that the use of "minor" elements as fertilisers for wheat grown on light land will not effect a substantial increase in baking quality. There is some indication that the application of ferrous sulphate may improve the baking quality slightly.

"Minor" elements, particularly zinc salts, may decrease the baking quality and should be used with great care.

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ACKNOWLEDGMENTS.

The author wishes to acknowledge the assistance of colleagues for provision of the samples and of the Forests Department in undertaking the statistical treatment of certain of the results.

Sheep Dipping—An Essential for Healthy Flocks.

HUGH MCCALLUM, Sheep and Wool Inspector.

Most flocks will now have been dipped, but it is considered imperative to issue a warning to those who have neglected to carry out this function, so essential to success in sheep husbandry.

Many clips inspected on the Show floors bear mute testimony of the lack of proper care and attention given to this phase of the wool industry, as the wools show discoloration, through using incorrectly mixed solutions, dipping at the wrong time of the year, etc., and poor quality, stain and damage from insect infestation.

Tick and lice are blood sucking parasites and infest all parts of the body of the animals. Their presence may be suspected when sheep are seen to rub themselves against logs, fence posts, etc.; a few sheep should then be caught and carefully examined in a strong lights as the parasites lie deep in the wool close to the skin.

The intense irritation caused by these sucking parasites upsets the sheep, making it restless and unable to settle to feed properly, with consequent loss of condition, while young sheep infested lose stamina and cannot develop. Their effect, however, is most apparent on the wool, which becomes roughened and dragged and considerably lessened in value. In the case of badly infested animals sometimes the skin is rubbed completely bare and often raw, and is thus an invitation to blow-fly attack.

Control of tick and lice is dependent upon dipping, which must be done at the right time, with the correct concentration of a suitable chemical (mixed strictly in accordance with the manufacturer's instruction) and so that the animal is completely immersed in the solution. This last proviso is very important, for if one animal escapes, or even dodges having its head submerged, it proves a harbour for

a few parasites which will quickly reproduce their species and re-infest the flock, thus rendering all the expense and time expended lost effort as far as maintaining a clean flock is concerned.

The ideal time to dip is from four to six weeks after shearing is completed, using any of the standard commercial preparations.

With the exercise of reasonable care in the observation of the following precautions, dipping can be made a safe and profitable practice.

(1) Do not dip in extremely hot or cold weather. Wait for a warm, fairly windless day.
(2) Do not dip hot, thirsty, or overfed sheep. Drive them to the yards the evening before and allow them time to rest and cool off.
(3) Commence dipping early and cease at least two hours before sundown to enable animals to dry off before nightfall.
(4) Completely immerse each animal at least once.
(5) Permit dipped sheep to drain in a pen before being released on to pasture, so that no poisonous material will be broadcast through the feed.
(6) Keep sucking lambs separate from mothers until the ewes have drained and dried out.

No. 4 can be accomplished by having one person stationed along the swim section of the dip armed with a pole to the end of which has been affixed a disc of smooth wood about 6in. in diameter, which is pressed just behind the shoulders of each sheep as it swims through, causing the animal to completely submerge but quickly come to the surface again.

In the case of No. 5, the fluid from the draining pen should run back into the dip and not be permitted to spread out over surrounding land, though as far as possible droppings from the animals should be swept into a shallow grated sump to prevent their contaminating the dipping solution.

After the ewes have been completely drained of solution the lambs should be returned to them in a small yard and care taken to see that each animal is "mothered" before nightfall.

After each batch of sheep have been dipped, the surface of the fluid can be skimmed with a fine wire sieve to remove scum of grease, burrs, etc., that forms on the top, and the bath well agitated by vigorously plunging the "prod" up and down to keep the chemical in solution.

The sheep farmer must come to realise the fact that unless he makes a determined effort to eradicate or control these parasites he cannot expect to farm at a profit. Sheep from infested flocks produce weakly lambs and those characteristically diseased looking clips which open up so unattractively in comparison with the bright clean fleeces of healthy animals.

In districts where small flocks are pastured the expense of providing a dip and handling yards on each holding is rather excessive but this difficulty can easily be overcome by the construction of a community dip at a convenient situation, the cost and maintenance of which can be shared evenly by all users.

By the high grade of some of her clips Western Australia has proved that she can produce wool comparable with the best from all other States of the Commonwealth, but this grade can only be maintained by care and attention to the flocks and it therefore behoves the sheep owner, not only to make his own livelihood a profitable on, but for the future of the State to practise only the best methods of sheep husbandry, and among these "dipping" is a principal.

Cereal Varieties Available for Distribution.

I. Thomas, Superintendent Wheat Farming.

The value of the use of the highest quality stock, with special regard to its productivity and disease resistance, has long been realised amongst stock breeders. With plants, these two same factors again play a most important part, a fact which is now realised by successful and progressive farmers.

For a cereal variety to be recommended and widely distributed amongst farmers it must be high yielding, disease and drought resistant, have satisfactory straw strength and threshing qualities and, with wheat, be of satisfactory milling and baking quality. In addition, the cereal variety must be suitable for the district in which it is to be grown, having particular regard to the prevailing climatic conditions and the purpose for which the crop is to be grown.

It is realised that quite a considerable number of farmers are not aware of the advantages to be gained from the use of pedigree seed, although they may regularly make use of pedigree stock. Many years ago even the grading of grain to be used for seed was considered so much waste of time (it was all wheat so why worry—sow it a bit heavy in case of accidents)—but the grading of ordinary commercial wheat for seed is not sufficient to ensure the use of the highest quality seed.

Experimental results have shown that though the use of graded seed has a definite advantage over ungraded seed, grading does not, however, prevent admixture of other varieties or maintain the particular variety at its highest yielding capacity.

It is not sufficient to produce new varieties by cross-breeding and selection over a number of years and then release them for general cultivation, but the different varieties must be maintained during subsequent years at the highest level of prolificacy. The maintaining of this high level can only be achieved by continual selection which is not a practical proposition on the ordinary farm.

One of the principal functions of the Agricultural Research Stations located in the Wheat Belt is and has been for many years, the production of selected pedigree seed of the standard varieties of wheat, oats and barley. In view of the highly specialised work, and facilities required, for the production, and maintenance of the purity, of this seed, the cost of this work is relatively high when compared with the commercial production of grain.

At each of two Research Stations, Merredin and Wongan Hills, a specialist is located, who, in addition to the breeding of new varieties, is required to carry out the initial stages and supervise the work involved in the raising of pedigree seed without which the high standard of quality and purity of the pedigree seed made available to settlers would not be possible.

At those Stations what are known as "Pure Line Breeding Rows" are conducted: these include rows of all the varieties which are distributed to settlers from these and the other Research Stations. Each year the most prolific plants having the typical characteristics of the varieties concerned are selected from the individual rows; the seed from these selections is then reserved for planting similar selection rows for the following year. The balance of the seed is harvested for planting in a larger area "The Accumulation Plot," from which the seed is obtained for the "Stud Plots" at the various Research Stations; these providing in their turn the seed for the "Bulk Plots" from which the farmer obtains his supplies of pedigree seed

As would be expected the work involved with the "Pure Line Breeding Rows" is most specialised. Each row is planted, tended and harvested by hand, each individual variety is separated one from the other by a buffer row of a different cereal and the selected individual heads are covered by transparent waterproof paper bags immediately prior to the flowering stage. Further, the individual varieties planted in the "Accumulation," "Stud" and "Bulk" plots are also kept separate by buffer plots of a different cereal. These plots are kept under constant supervision for any signs of variation and all wheat varieties planted are each year tested for their resistance to flag smut. In the case of new wheat varieties these are tested in the Cereal Research laboratory to determine their milling and baking qualities, as no new wheat variety is released for general cultivation unless it is at least equal in these qualities to the variety which it is intended to replace.

It will thus be seen that the seed obtained by the farmer is the direct result of the selection of a single plant which developed from a single seed. Only in this way is it possible to maintain the purity and high yielding capacity of the variety.

When making available supplies of pedigree seed, produced at the Agricultural Research Stations, for distribution to farmers, it is not possible for farmers to obtain all of their seed requirements in this way from the Department. It is recommended, however, that each year they should obtain a few bags of pedigree seed of the variety or varieties they normally grow, sow this seed in a "Stud Plot" or plots and then use the grain obtained for their seed requirements the following year. In this way, farmers are enabled to maintain the prolificacy of the different varieties grown by them at a relatively small cost.

Furthermore, the aim of the Department is to supply as many farmers as possible with pedigree seed and thus, owing to the fact that the demand for some of the varieties is greater than the supply, it is often necessary to limit the amount of each variety supplied to any one applicant in order that he may be able to obtain at least some pedigree seed.

It is anticipated that this year the following varieties will be available for distribution—

WHEAT.

Baroota Wonder.—A late maturing variety, resistant to flagsmut, but is liable to rust. This variety is recommended for hay in the better rainfall districts.

Bencubbin.—A midseason maturing variety, resistant to flagsmut, but is very liable to rust and is not recommended for those districts where rust is feared.

Bungulla.—A selection from Bencubbin, early maturing, drought resistant variety, resistant to flagsmut, susceptible to rust, but tends to be rust escaping on account of its early maturity.

Carrabin.—An early maturing variety of high quality grain; resistant to flagsmut and rust escaping.

Comeback.—An early-midseason maturing variety of premium milling quality. It is resistant to flagsmut and rust escaping.

Ford.—A midseason maturing variety, resistant to flagsmut and rust.

Geeralying.—A very early maturing variety, resistant to flagsmut and rust escaping. It is liable to shed.

Gluyas Early.—An early maturing variety; resistant to rust but liable to flagsmut.

Merredin.—An early maturing variety, susceptible to flagsmut, but rust escaping.

Nabawa.—A midseason maturing variety, resistant to flagsmut and rust. Recommended for those areas where rust is feared.

Noongaar.—A very early maturing variety which is drought resistant, being most suitable for areas having a short growing period and for very late planting in those districts having a better rainfall; resistant to flagsmut and rust escaping.

S.H.J.—An early maturing variety producing a grain of high milling quality. It is resistant to flagsmut and rust.

Sutton.—A late maturing variety, resistant to flagsmut and moderately resistant to rust. This variety is not recommended for areas of low rainfall.

Totadgin.—An early maturing variety; resistant to flagsmut.

OATS.

Algerian.—Late maturing variety. Owing to slow early growth it is not recommended for early green feed.

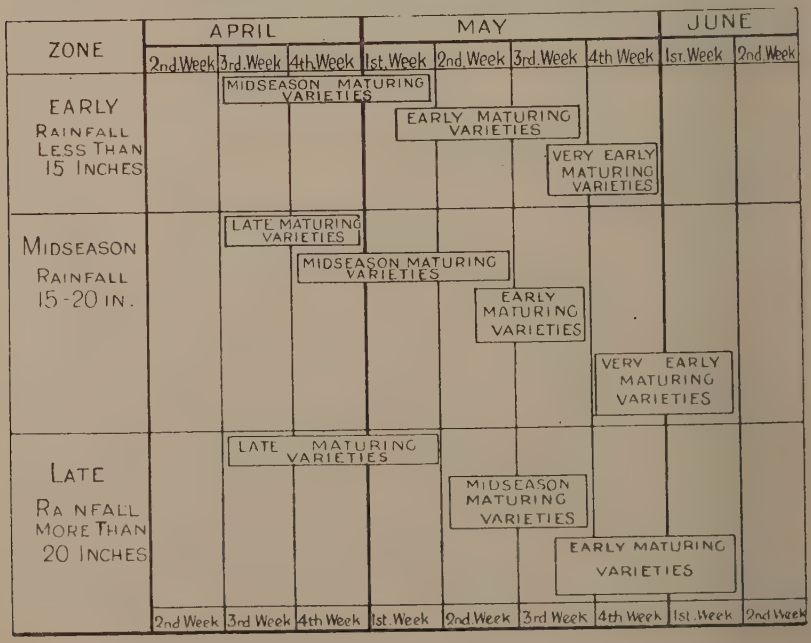
Burt's Early.—An early maturing variety which is especially suitable for hay, silage and early green feed.

Guyra.—A midseason maturing variety mostly favoured for its grain which is large and plump.

Mulga.—An early maturing variety suitable for hay, grain, silage and early green feed; superior to Burt's Early for grain.

Wongan.—A very early maturing variety which was produced at the Wongan Hills Research Station from a cross between Mulga and Burt's Early. It has short, strong straw and is suitable for early green feed and grain in the drier areas or for late planting in the wetter districts.

SEEDING CALENDAR WITH RECOMMENDED VARIETIES FOR THE WESTERN AUSTRALIAN WHEAT BELT.



RECOMMENDED VARIETIES.

Late Maturing.	Midseason Maturing.	Early Maturing.	Very Early Maturing.
Wheat— Sutton, Yandilla King, Baroota Wonder (for Hay)	Bencubbin, Ford, Nabawa	Gluyas Early, Merredin, Totadgin, Bungulla Premium Varieties— Carrabin, Comeback, Pusa IV., S.H.J.	Geeralying, Noongaar.
Oats— Algerian	Guyra	Burt's Early, Mulga	Wongan.

When planting for hay, sow 7–10 days earlier than for grain.

BARLEY.

Atlas.—A six-rowed barley which has been introduced from California, it is also known in this State as Californian Six-Row Barley. In England it is used for malting purposes, but it is not employed for this purpose by local brewers whose technique is based on the use of two-row barleys such as Pryor. It is grown mainly for green feed and is quite equal in this respect to Cape, Bald Skinless or Black Barley, while for grain its yield is superior to Cape.

Applications for pedigree seed should be made *direct* to the Department of Agriculture, Perth.

The seed may be obtained either on a cash basis or under the Exchange System, which has operated for the past few years, when the farmer has been able to exchange his own f.a.q. wheat for pedigree seed on the following basis:—

4½ bushels f.a.q. wheat for 3 bushels pedigree seed wheat or barley.
3 bushels f.a.q. wheat for 3 bushels pedigree seed oats.

Both of these transactions are inclusive of rail freight on the seed to the settler's siding.

Applicants are advised to make early application for their requirements, setting out clearly their name and postal address, together with the siding to which the seed is to be railed.

Fertilisers.

H. G. CARISS,
Assistant Inspector of Fertilisers.

The new fertiliser year commenced on the 1st November, 1939, and in accordance with the Fertiliser Act, 1928, the list of fertilisers registered for the current year are appended hereunder in tabular form.

Under the provisions of the Fertiliser Act, 1928, and the regulations thereunder, it is provided that all fertilisers sold in this State shall be registered, sold under a registered brand and in a package on which is conspicuously marked a copy of the registered brand and the name of the fertiliser. The act of registering a fertiliser is a form of guarantee to the consumer that he is obtaining what

he is paying for. Also, in order to ensure that the material demanded and paid for is supplied it is encumbent upon the seller, provided that the quantity sold is one hundredweight or more, to issue an invoice, on the prescribed form, with each sale, and include on the invoice the minimum percentages of the fertilising ingredients and, when applicable, other particulars such as fineness, etc.

Furthermore, inspectors are appointed under the Act, and, during the year, periodical inspection of the places where fertilisers are kept for sale or sold are made, and samples taken and submitted to the Government Analyst for analysis.

Manufacturers, as a rule, aim at keeping the analysis of their different fertilisers close to the guaranteed figures as an indication of care in manufacturing and dependability of their product.

From time to time brands of fertilisers make their appearance on the market, especially so-called special garden manures, which are supposed to be a panacea for all plant evils, and on analysis are found to be either worthless or far more costly than their ingredients would justify. Such fertilisers should be treated with caution and information sought from the Department of Agriculture as to their registered analyses and comparable values.

As a guide to agriculturists in purchasing their manures the unit values for the different forms of the main fertilising ingredients, nitrogen, phosphoric acid and potash, have been calculated from the quoted prices per ton.

The system of units and unit values enables an approximation of the comparative monetary values of similar fertilisers to be made. At first sight it may appear that a comparison of the quoted costs per ton would be satisfactory, but as the registered minimum percentages of the fertilising ingredients are not always similar this is not so.

The amount of a fertilising ingredient in a fertiliser, *e.g.*, nitrogen in sulphate of ammonia, is measured in terms of units, one unit being one per cent. by weight per ton. Therefore, the unit value for nitrogen in sulphate of ammonia containing 20 per cent. nitrogen and costing £12 per ton would be £12/20 or 12s.

In a similar way the unit values for the other fertilising ingredients in their various forms may be obtained. Though these unit values approximate fairly closely to the fertilising value, it must be clearly understood that they are not the definite value but are governed by the current market rates. Further, the total of the individual unit values in each fertiliser is not necessarily equal to the quoted price as the calculated values are averages of all the fertilisers of that class offered for sale. Also with mixed mineral fertilisers, *viz.*, potato manures, etc., the cost of mixing and extra handling must be added to the cost of the ingredients, but the unit values still serve as a definite guide to the relative usefulness of the different mixtures for any specific purpose.

To illustrate this comparison by unit values a simple example will serve, say—

	Minimum percentages of Nitrogen.	Phosphoric Acid.	Quoted price per ton.
X. brand blood and bone ..	6.5	10	£12
Y. brand blood and bone ..	5.5	13	£12

From the appended table of unit values for the current fertiliser year, that for nitrogen in blood and bone is 22s. 4d. and for phosphoric acid 5s. 7d. therefore, using these figures we now obtain the computed value for each fertiliser—

X Brand Blood and Bone.	s.	d.
6.5 units of nitrogen at 22s. 4d. per unit	145	2
10 units of phosphoric acid at 5s. 7d. per unit	55	10
Total value	201	0

Y Brand Blood and Bone.	s.	d.
5.5 units of nitrogen at 22s. 4d. per unit	122	10
13 units of phosphoric acid at 5s. 7d. per unit	72	7
Total value	195	5

It will be seen, therefore, that as the units contained in X brand are worth more than those of Y brand the former would be the more economical fertiliser to purchase when they are both priced at £12 per ton.

Unit values should be used only in comparing fertilisers of similar types, as manufacturing costs vary greatly with the class of fertiliser as also do the length of time and extent to which the fertilising ingredients become available. For instance, the nitrogen as nitrate or ammonia is readily available and unit values should not be used in comparing either of them with that as blood and bone or bone dust which are less readily available.

The main variations from last year's values are a decrease in blood and bone and bone dust for organic nitrogen and phosphoric acid of 1s. 8d. and 5d. per unit respectively and an increase of 9d. per unit for ammoniacal nitrogen. The values for the other fertilisers have remained constant.

It must be noted that due to the present world situation these unit values are subject to alteration, but will still serve as a guide for comparison of similar types of fertilisers.

In the table hereunder the unit values for the current year are shown in comparison with those for the previous three seasons.

UNIT VALUES.

	1936–37.	1937–38.	1938–39.	1939–40.
	s. d.	s. d.	s. d.	s. d.
Nitrogen (N) as—				
Dried Blood	...	...	...	26 0
Blood and Bone, Bonedust and Bone and Flesh ...	21 8	23 0	24 0	22 4
Nitrate	18 2	18 1	18 1	18 1
Ammonia	11 8	11 3	11 2	11 11
Phosphoric Acid (P_2O_5) as—				
Water soluble as superphosphate	3 4	3 3	3 3	3 3
Citrate soluble as superphosphate	3 4	3 3	3 3	3 3
Blood and Bone, Bonedust and other animal fertilisers	5 6	5 9	6 0	5 7
Basic Phosphate	4 11	4 11	4 11	4 11
Acid soluble in superphosphate and rock phosphate	2 2	2 2	2 2	2 2
Potash (K_2O) as—				
Sulphate	6 4	6 5	6 5	6 5
Muriate	5 6	5 7	5 7	5 7

FERTILISERS.

The following fertilisers have been registered at the Department of Agriculture under the Fertilisers Act, 1928, for the year commencing 1st November, 1939:—

Name of Fertiliser.	Reg. No.	Brand.	By whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on rails at Works † or Perth.‡
				Nitrate.	Ammonia.	Blood and Bone	Bone-dust.	Water sol.	Citrate sol.	Acid sol.	Total.	Sulphate.	Muriate.	
A.—MINERAL.				%	%	%	%	%	%	%	%	%	%	£ s. d.
1. NITROGENOUS:														
(a) *Nitrogen as Nitrate:*														
Nitrate of Soda	33	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	15·5	....	....	....	....	....	....	....	....	....	†14 0 0
Do.	61	ML (in diamond)	do. do.	15·5	....	....	....	....	....	....	....	....	....	†14 0 0
Do.	89	CSML	do. do.	15·5	....	....	....	....	....	....	....	....	....	†14 0 0
Do.	117	Cresco	Cresco Fertilisers (W.A.), Ltd.	15·5	....	....	....	....	....	....	....	....	....	†14 0 0
(b) *Nitrogen as Ammonia:*														
Sulphate of Ammonia	9	ICIANZ	Nitrogen Fertilisers, Ltd.	....	20·6	....	....	....	....	....	....	....	....	†12 5 0
Do.	32	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	20·5	....	....	....	....	....	....	....	....	†12 5 0
Do.	60	ML (in diamond)	do. do.	....	20·5	....	....	....	....	....	....	....	....	†12 5 0
Do.	88	CSML	do. do.	....	20·5	....	....	....	....	....	....	....	....	†12 5 0
Do.	114	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	20·5	....	....	....	....	....	....	....	....	†12 10 0
2. PHOSPHATIC—														
(a) *Rock Phosphate:*														
Pacific Islands Phosphate	31	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	....	....	36·65	36·65	....	....	† 4 0 0
Do.	59	ML (in diamond)	do. do.	....	....	....	....	....	....	36·65	36·65	....	....	† 4 0 0
Do.	92	CSML	do. do.	....	....	....	....	....	....	36·65	36·65	....	....	† 4 0 0
Phosphate Powder	113	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	....	....	36·65	36·65	....	....	† 4 0 0
(b) *Superphosphate:*														
Florida Superphosphate, 22 per cent.	10	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	20·5	0·5	1·0	22·0	....	....	† 3 12 6
Florida Superphosphate, 23 per cent.	11	do.	do. do.	....	....	....	....	21·25	0·5	1·25	23·0	....	....	† 3 12 6
22 per cent. Superphosphate	38	ML (in diamond)	do. do.	....	....	....	....	20·5	0·5	1·0	22·0	....	....	† 3 12 6
High Grade Superphosphate, 23 per cent.	39	do. do.	do do.	....	....	....	....	21·25	0·5	1·25	23·0	....	....	† 3 12 6
22 per cent. Superphosphate	66	CSML	do. do.	....	....	....	....	20·5	0·5	1·00	22·0	....	....	† 3 12 6
High Grade Superphosphate, 23 per cent.	67	do.	do. do.	....	....	....	....	21·25	0·5	1·25	23·0	....	....	† 3 12 6
"23" Superphosphate	97	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	21·25	0·5	1·25	23·0	....	....	† 3 12 6

(c) Rock Phosphate and Superphosphate:															
Phosphate Mixture 50/50	30	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....		....	....	10·0	0·5	18·5	29·0	....	....	† 4 1 6	
Do.	58	ML (in diamond)	do. do.	....				10·0	0·5	18·5	29·0			† 4 1 6	
Do.	87	CSML	do. do.	....				10·0	0·5	18·5	29·0			† 4 1 6	
50/50 Phosphate	98	Cresco	Cresco Fertilisers (W.A.), Ltd.					10·0	0·5	18·5	29·0			† 4 1 6	
(d) Basic Phosphate:															
Basic Phosphate	29	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	....	....	17·0	17·0	....	....	† 4 4 0	
Do.	57	ML (in diamond)	do. do.	....	....	....	....	....	....	17·0	17·0	....	....	† 4 4 0	
Do.	78	CSML	do. do.	....	....	....	....	....	....	17·0	17·0	....	....	† 4 4 0	
3. POTASSIC—															
(a) Potash as Sulphate:															
Sulphate of Potash	34	Sickle	do. do.	....	....	....	..	..		.	..	48·6	.	†15 10 0	
Do.	62	ML (in diamond)	do. do.	....	....	....	..	..		.	..	48·6	....	†15 10 0	
Do.	90	CSML	do. do.	....	....	....	....	....	....	....	....	48·6	....	†15 10 0	
Do.	115	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	....	....	....	....	48·6	....	†15 10 0	
Do.	121	Palestine	George Wills & Co., Ltd.	....	....	....	..	..	....	..	....	48·6	....		
Do.	125	Sun	West Farmers, Ltd.	....	....	....	..	..	....	..	....	48·6	....	§	
(b) Potash as Muriate															
Muriate of Potash	35	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	.	....	....	....	....	....	....	....	....	50·0	†14 0 0	
Do.	63	ML (in diamond)	do. do.	....	....	....	....	....	....	....	....	....	50·0	†14 0 0	
Do.	91	CSML	do. do.	....	....	....	....	....	....	....	....	....	50·0	†14 0 0	
Do.	116	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	....	....	....	....	....	50·5	†14 0 0	
Do.	122	Palestine	George Wills & Co., Ltd.	....	....	....	....	..	....	....	..	....	50·0		
Do.	128	Sun	Westralian Farmers, Ltd.	....	....	....	.	..	....	....	..	....	50·0		
Kainit	124	do.	do. do.	....	....	....	....	....	....	....	....	....	50·0		
Potash Manure Salts	127	do.	do. do.	....	..	....	....	....	....	....	....	....	14·0		
													30·0		
4. NITROGEN AND PHOSPHORIC ACID—															
Super and Ammonia, No. 1	22	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.		2·94	....	....	17·57	0·43	0·85	18·85	....	....	† 5 10 6	
Do. No. 2	23	do.	do. do.	...	5·15	....	....	15·37	0·37	0·76	16·50	....	....	† 6 10 0	
Do. No. 3	24	do.	do. do.	....	6·0	....	....	14·25	0·4	1·1	15·75	....	....	† 6 15 0	
Do. No. 4	25	do.	do. do.	....	6·87	....	....	13·66	0·34	0·66	14·66	....	....	† 7 4 0	
Do. No. 5	26	do.	do. do.	...	10·30	.		10·25	0·25	0·50	11·00	..	..	† 8 14 0	
Do. No. 1	50	ML (in diamond)	do. do.	.	2·94	....	...	17·57	0·43	0·85	18·85	....	..	† 5 10 6	
Do. No. 2	51	do. do.	do. do.	....	5·15	....	....	15·37	0·37	0·76	16·50	....	....	† 6 10 0	
Do. No. 3	52	do. do.	do. do.	....	6·0	....	....	14·25	0·4	1·1	15·75	....	....	† 6 15 0	
Do. No. 4	53	do. do.	do. do.	....	6·87	....	....	13·66	0·34	0·66	14·66	....	....	† 7 4 0	
Do. No. 5	54	do. do.	do. do.	....	10·3	....	....	10·25	0·25	0·50	11·0	....	....	† 8 14 0	
Do. No. 1	82	CSML	do. do.	....	2·94	....	....	17·57	0·43	0·85	18·85	....	....	† 5 10 6	

§ Prices on application.

FERTILISERS—*continued.*

Name of Fertiliser.	Reg. No.	Brand.	By whom Registered	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on rails at Works † or Perth. ‡
				Nitrate.	Ammonia.	Blood and Bone	Bone-dust.	Water sol.	Citrate sol.	Acid sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
4. NITROGEN AND PHOSPHORIC ACID—*continued.*														
Super and Ammonia, No. 2	83	CSML	Cuming Smith & Mt. Lyell F.F. Ltd.	....	5·15	....	....	15·37	0·37	0·76	16·50	..	..	† 6 10 0
Do. No. 3	84	do.	do. do.	....	6·0	....	....	14·25	0·4	1·1	15·75	....	....	† 6 15 0
Do. No. 4	85	do.	do. do.	...	6·87	....	..	13·66	0·34	0·66	14·66	....	..	† 7 4 0
Do. No. 5	86	do.	do. do.	....	10·3	..	...	10·25	0·25	0·5	11·0	.	.	† 8 14 0
Do. 6 : 1	99	Cresco	Cresco Fertilisers (W.A.), Ltd.	...	2·94	.	..	17·57	0·43	0·85	18·85	.	.	† 5 10 6
Do. 3 : 1	100	do.	do. do.	....	5·15	....	....	15·37	0·37	0·76	16·30	....	....	† 6 10 0
Do. 2 : 1	101	do.	do. do.	...	6·87	..	..	13·66	0·34	0·66	14·66	....	....	† 7 4 0
Do. 1 : 1	102	do.	do. do.	..	10·3	.	.	10·25	0·25	0·5	11·0	.	.	† 8 14 0
Potato Manure C ..	13	Sickle .. .	Cuming Smith & Mt. Lyell F.F., Ltd.	.	3·5	.	.	16·75	0·40	1·10	18·25	..	.	† 5 16 0
Do. F ..	15	do.	do. do.	....	6·0	....	.	14·25	0·40	1·10	15·75	..	..	† 6 15 0
Do. No. 2	40	ML (in diamond)	do. do.	..	3·5	....	....	16·75	0·40	1·1	18·25	..	..	† 5 16 0
Do. No. 6	44	do. do.	do. do.	..	6·0	....	.	14·25	0·40	1·1	15·75	.	.	† 6 15 0
Do. C	69	CSML	do. do.	...	3·5	....	....	16·75	0·4	1·1	18·25	....	....	† 5 16 0
Do. F ...	71	do.	do. do.	.	6·0	....	.	14·25	0·4	1·1	15·75	.	.	† 6 15 0
Phosphate of Ammonia	134	Floraphos ..	J. A. Newman & Co.	..	15·6	....	..	31·20	....	..	31·20	....	..	†35 0 0
5. NITROGEN, PHOSPHORIC ACID AND POTASH—														
Potato Manure B ...	12	Sickle ..	Cuming Smith & Mt. Lyell F.F. Ltd.	...	3·75	....	....	14·5	0·35	0·75	15·6	4·5	....	† 7 2 0
Do. E	14	do.	do. do.	....	3·5	....	....	14·0	0·3	0·7	15·0	8·0	....	† 7 19 0
Do. G	16	do.	do. do.	....	3·5	...	..	10·5	0·2	0·6	11·3	16·0	..	†10 0 0
Do. H	17	do. ..	do. do.	...	4·0	.	.	12·7	0·3	0·7	13·7	9·0	.	† 8 8 0
Do. No. 5	18	do.	do. do.	...	7·5	.	.	7·0	0·2	0·4	7·6	13·25	.	†11 1 0
Orchard Manure .	19	do.	do. do.	...	2·0	.	.	15·75	0·4	1·1	17·25	.	5·0	† 6 6 0
Special Mixture K	20	do.	do. do.	...	8·34	....	..	8·4	0·2	0·4	9·0	....	10·04	†10 2 6
Do. KP	21	do.	do. do.	....	6·34	.	.	10·5	0·2	0·8	11·5	10·04	....	† 9 13 0
Tobacco Fertiliser	28	do.	do. do.	3·3				14·0	0·5	1·0	15·5	5·7	..	† 7 10 0
Potato Manure No. 3	41	ML (in diamond)	do. do.		3·75	.	.	14·5	0·35	0·75	15·6	4·5	.	† 7 2 0
Do. No. 4	42	do. do.	do. do.	...	3·5	.	.	14·0	0·3	0·7	15·0	8·0	..	† 7 19 0
Do. No. 5	43	do. do.	do. do.		7·5	.		7·0	0·2	0·4	7·6	13·25	..	†11 1 0
Do. No. 7	45	do. do.	do. do.	.	3·5	.		10·5	0·2	0·6	11·3	16·0	..	†10 0 0
Do. No. 8	46	do. do.	do. do.	.	4·0	.		12·7	0·3	0·7	13·7	9·0	.	† 8 8 0
Orchard Manure	47	do. do.	do. do.	.	2·0			15·75	0·4	1·1	17·25	..	5·0	† 6 6 0
Special Mixture K	48	do. do.	do. do.	.	8·34	.		8·40	0·2	0·4	9·0		10·04	†10 2 6
Do. KP	49	do. do.	do. do.		6·34			10·5	0·2	0·8	11·5	10·04	..	† 9 13 0
Tobacco Fertiliser	56	do. do.	do. do.	3·3				14·0	0·5	1·0	15·5	5·7	.	† 7 10 0
Potato Manure B ..	68	CSML	do. do.	....	3·75	....	....	14·5	0·35	0·75	15·6	4·5	....	† 7 2 0
Do. E	70	do.	do. do.	....	3·5	....	....	14·0	0·3	0·7	15·0	8·0	....	† 7 19 0

Do. G	72	do.	do. do.			3·5			10·5	0·2	0·6	11·3	16·0	....	†10 0 0
Do. H	73	do.	do. do.			4·0			12·7	0·3	0·7	13·7	9·0	....	† 8 8 0
Do. No. 5	74	do.	do. do.			7·5			7·0	0·2	0·4	7·6	13·25		†11 1 0
Orchard Manure	79	do.	do. do.			2·0			15·75	0·4	1·1	17·25		5·0	† 6 6 0
Special Mixture K	80	do.	do. do.			8·34			8·4	0·2	0·4	9·0		10·04	†10 2 6
Do. KP	81	do.	do. do.			6·34			10·5	0·2	0·8	11·5	10·04	...	† 9 13 0
Tobacco Fertiliser	76	do.	do. do.		3·3				14·0	0·5	1·0	15·5	5·7	....	† 7 10 0
Do. No. 2	77	do.	do. do.		3·7				13·2	0·3	0·7	14·2	7·0	...	† 7 14 0
Potato Special	104	Cresco	Cresco Fertiliser (W.A.), Ltd.	...		4·0	....	....	12·7	0·3	0·7	13·7	9·0	....	† 8 8 0
Potato Manure	105	do.	do. do.	...		1·5	...	...	7·1	1·4	13·5	22·0	7·5	....	† 6 15 0
Vine Manure	108	do.	do. do.			1·5	..	....	7·10	1·40	13·5	22·0	7·5	....	† 6 15 0
Orchard Manure	106	do.	do. do.	..		1·5	...	..	7·10	1·40	13·5	22·0	7·5	...	† 6 15 0
Mixed Manure	107	do.	do. do.	..		1·5	....	.	7·10	1·40	13·5	22·0	7·5	...	† 6 15 0
Special Orchard	103	do.	do. do.			8·34	...		8·4	0·2	0·4	9·0	..	10·04	†10 2 6
Potato Manure	129	Eclipse	West Australian Meat Export Co., Ltd.			3·0	....	....	16·0	....	0·25	16·25	....	4·25	† 7 5 0
6. MISCELLANEOUS															
Super and Manganese*	112	Cresco	Cresco Fertiliser (W.A.), Ltd.	....		....	....	....	17·0	0·5	1·0	18·5	....	....	† 7 10 0
B.—ORGANIC.															
(*a*) *Blood and Bone:*															
Animal Fertiliser	1	State Abattoirs, Midland Junction	State Abattoirs, Midland Junction	....		8·0	...	..	...	5·0	5·0	....	....	†10 0 0
Blood and Bone	2	"Wyndham" ..	Wyndham Freezing, Canning and Meat Export Works	....	..	6·0	....	....	6·0	6·5	12·5	....	....	‡10 5 0
Do.	3	Fitzroy	W. Angliss & Co. (Aust.) Pty., Ltd.	....	....	5·0	....	....	6·0	12·0	18·0	....	....	‡ 8 5 0
Do.	5	A.N.A. Surprise ..	C. A. Kirby & Sons ..	....	..	5·0	..	..	4·0	10·0	14·0	....	....	‡10 15 0
Do.	6	Apollo	J. Kitchen & Sons Pty., Ltd.	....	..	7·0	....	....	....	....	14·0	....	....	‡10 10 0
Do. (Brooklyn)	7	TB & S (in diamond)	Thos. Borthwick & Sons (Aust.), Ltd.	....	....	5·75	....	....	5·75	6·0	11·75	....	....	† 8 10 0
Do.	36	Sickle	Cuming Smith & Mt. Lyell F.E., Ltd.	....	....	5·0	....	....	....	15·0	15·0	....	....	†10 0 0
Do.	64	ML (in diamond)	do. do.	..	..	5·0	...	..	..	15·0	15·0	....	....	†10 0 0
Do.	94	CSML	do. do.	....	..	5·0	..	..	...	15·0	15·0	..	..	†10 10 0
Do. G	95	do.	do. do.	....	..	6·0	....	...	....	12·0	12·0	....	....	†10 10 0
Do. (Wyndham)	109	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	..	6·25	....	..	..	12·0	12·0	..	....	†10 10 0
Do.	119	Albany Freezing Works, Ltd.	Albany Freezing Works, Ltd.	....	....	6·0	....	....	....	....	12·0	....	....	†10 0 0
Do.	120	A1 (in circle)	Haynes & Clements	....		5·25	..	3·0	9·0	12·0				‡10 10 0
Do.	133	Robbs	West Australian Meat Export Co., Ltd.	....		5·25	.	.	14·0	14·0				† 9 15 0
Do.	132	Eclipse	do. do.	....	....	6·0	....	....	....	12·0	12·0	....	....	†10 0 0
Do.	126	Sun	Westrallan Farmers, Ltd.	....	....	5·25	....	....	....	....	14·0	....	....	† 8 15 0

* Contains 5·75% Manganese as MnO_2.

FERTILISERS—*continued.*

Name of Fertiliser.	Reg. No.	Brand.	By whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on rails at Works † or Perth. ‡
				Nitrate.	Ammonia.	Blood and Bone	Bone-dust.	Water sol.	Citrate sol.	Acid sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
6.—MISCELLANEOUS—*continued.*														
(*b*) *Bones :*														
Bonedust	93	CSML	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	3·5	....	....	22·0	22·0	....	....	†11 0 0
Do.	110	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	3·5	....	....	22·0	22·0	....	....	†11 0 0
Do.	130	Eclipse	West Australian Meat Export Co., Ltd.	....	....	....	3·5	....	....	22·0	22·0	....	....	† 7 10 0
(*c*) *Blood :*														
Dried Blood	4	Fitzroy	W. Angliss & Co. (Aust.) Pty., Ltd.	....	....	12·0	....	....	....	....	....	....	....	‡15 10 0
C—MINERAL AND ORGANIC.														
Bone and Super.	27	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....		2·0	13·0	0·8	4·7	18·5	....	....	† 6 17 6
Do.	55	ML (in diamond)	do. do.	....	....		2·0	13·0	0·8	4·7	18·5	....	....	† 6 17 6
Do.	78	CSML	do. do.	....	....		2·0	13·0	0·8	4·7	18·5	....	....	† 6 17 6
Special Mixture for Lawns*	37	Sickle	do. do.	....		6·94	..	3·95	0·23	5·67	9·85	6·02	..	†12 0 0
Do. do. *	65	ML (in diamond)	do. do.	....		6·94	..	3·95	0·23	5·67	9·85	6·02	..	†12 0 0
Do. do. *	96	CSML	do. do.	....		6·94	..	3·95	0·23	5·67	9·85	6·02	..	†12 0 0
Bone, Super. and Potash	111	Cresco	Cresco Fertilisers (W.A.) Ltd.	....		....	1·0	..	..	14·0	14·0	1·0	..	† 4 17 6
Special Mixture 140*	118	do.	do. do.	....		6·94	....	3·95	0·23	5·67	9·85	6·02	....	†12 10 0
Manurial Insecticide	8	Kill-a-Mite	Thomas Agency	....	2·02		..	....	....	....	3·76	..	2·51	....
Fertos	123	Floreat	T. S. McGill	....	9·38	....	....	15·0	0·5	1·55	17·05	..	....	†20 0 0
B.S.P.	131	Eclipse	West Australian Meat Export Co., Ltd.	....	1·20	....	....	5·0	..	9·0	14·0	....	1·20	† 5 0 0

* Contains traces of magnesium, iron, copper, zinc and manganese as sulphates.

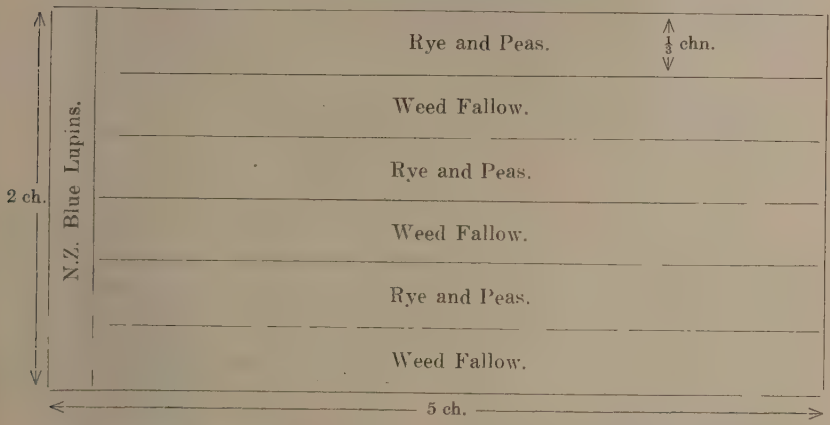
Variety and Fertiliser Experiments with Tobacco at Manjimup—Season 1938-39.

W. P. CASS SMITH, Plant Pathologist.*

A. SHARP, Tobacco Adviser.

The programme of field experiments with tobacco for the season 1938-39 was again carried out on Mr. G. F. Combs's property at Jardee, and the area utilised was that on which the previous season's experimental crop had been grown. The area, which measured 5 chains by 2 chains, was ploughed and cultivated during the third week of April, 1938, and divided into six strips each one-third of a chain wide. Alternate strips were sown on 28th April with a green manure crop consisting of a mixture of rye and field peas at the rate of 2 bushels of rye and 1 bushel of peas per acre, together with a dressing of superphosphate at the rate of one bag (180 lbs. approx.) per acre. A plot measuring 2 chains by one-third chain at one end of the area was sown with New Zealand Blue Lupin on the following day, and the remainder of the area was left unsown. The seed of each legume was inoculated with the appropriate strain of nitrogen-fixing bacteria according to Departmental recommendations.

DIAGRAM OF LAYOUT OF GREEN MANURE PLOTS.



An excellent germination of rye, peas and lupins was obtained and by the middle of August the crop was standing between three and four feet high while the unsown strips were carrying a fairly prolific growth of capeweed. The area was ploughed on the 23rd and 24th of August and then cultivated with a disc cultivator. It was cross ploughed on the 25th and the 26th of October, by which time the lupins and peas had completely decomposed and only a very little rye straw was in evidence. The ground was worked down to a fine tilth with harrows, and the furrows were opened to receive the fertilizer on the 28th of October. Except where stated otherwise 1,000 lbs. of standard tobacco fertiliser was applied per acre, the composition being as follows:—

Sulphate of ammonia	120	lbs.
Nitrate of soda	60	„
Superphosphate	700	„
Sulphate of potash	120	„

*Officer in charge of Tobacco Investigations.

Planting was completed by the 7th of November, a plentiful supply of well-grown, healthy seedlings being available from the Department's own seed-beds at Manjimup. An excellent strike was obtained, very little replanting being necessary. Continuous horse and hand cultivation was carried out throughout the growing season. Some field infection of downy mildew (blue mould) occurred early in December, but the damage done was confined to some spotting of the bottom leaves.

Climatic conditions experienced up to the middle of January were rather more favourable than usual and the crop generally promised to be an excellent one. Topping was carried out during the second week of January. It was anticipated that the harvesting of the bottom leaves would commence on the 23rd of January, but unfortunately heavy soaking rain fell on the three previous days, washing the gum off the leaves and rendering them unfit to pick. Unsettled weather was experienced until the middle of February, and the resulting thorough saturation of the soil caused a fresh flow of sap in the plants, which had the effect of reverting the almost mature leaf to an immature condition. Harvesting eventually commenced on the 27th of February, having been delayed five weeks. The effect of the extremely unusual weather conditions was to coarsen the leaf, render it rather difficult to cure, and seriously reduce the proportion of bright leaf which might otherwise have been obtained.

Five pickings were obtained at weekly intervals, the final picking being made on the 27th of March: by this time low night temperatures were definitely exercising a detrimental effect on the leaf. As each cure was completed the leaf from each plot was carefully labelled and placed in bulk where it remained until the third week in June. The leaf from each plot was then weighed, graded, and the weight and estimated value per lb. of each grade recorded.

Green Manuring.

Throughout the season careful note was made of the effect on the tobacco of the green manure crops. As the season progressed it became obvious that the crop growing on land where lupins had been ploughed in would be extremely heavy. However, this crop did not mature normally, the leaf retaining its dark green colour until late in the autumn when it tended to perish from the tips backward. As was to be expected, it was impossible to cure this leaf a good colour and it was of no commercial value. It has previously been noticed on several occasions that maturity and quality are adversely affected when tobacco is grown immediately after lupins, and it is reasonable to assume that this effect is due to the fixation of excessive quantities of nitrogen by this legume.

It is possible therefore that in such cases normal maturation and quality would be obtained by considerably reducing the amount of applied nitrogenous fertilisers, a point worthy of further investigation, especially at the present time when available supplies of these fertilisers are limited.

The difference between the crop grown on soil in which rye and peas had been planted and that on weed fallow was less than was anticipated. If anything, the green manured area produced a more even growth of tobacco, but the total yields and leaf values from the two treatments did not differ significantly. However the unseasonable weather experienced just as the crop approached maturity may have obscured any effect of treatment.

Variety Experiment.

The following eleven varieties were included in this experiment:—

1. *Hickory Prior.*—Standard variety in this State for a number of years.

2. *Gold Dollar.*—Popular in Queensland. Not previously grown in Western Australia.

3. *Kelly.*—Introduced three years ago from New South Wales. Has given very promising results here.

4. *Cash.*—Introduced five years ago from America. Has previously given excellent results and is popular with growers.

5. *Bonanza.*—Introduced three years ago from Queensland and has given good results.

6. *Dungowan.*—Being tested here for the first time. Largely grown in Victoria owing to supposed resistance to Blue Mould.

7. *Dungowan Selection.*—An improved strain of Dungowan.

8. *No. 35 White Stem Orinco.*—Newly introduced from America.

9. *Yellow Mammoth.*
10. *White Mammoth.* } Both these are newly introduced from America.

11. *Harrow Velvet.*—A light Burley variety suitable for air curing. Newly introduced from America.

The experiment was arranged in the form of a randomised block with four separately randomised replications of each variety Each plot consisted of 20 plants spaced at 2 ft. intervals in rows 4 ft. apart. Half of each plot was planted in soil green-manured with rye and peas and half on weed fallow. Standard tobacco fertiliser was applied in the rows at a depth of approximately four inches at the rate of 1,000 lbs. per acre. The plants were set out on the 31st of October.

About the end of November slight infection by downy mildew (blue mould) was observed on all varieties, the burley variety "Harrow Velvet" appearing, if anything, to be the most susceptible to this disease. "Dungowan" and "Dungowan Selection" showed infection to an extent about equal to the other varieties, but the incidence of the disease was much too slight to enable any opinion to be formed regarding their ability to resist serious attack.

All varieties made good growth. "Dungowan" and "Dungowan Selection" were particularly vigorous, but produced very large, coarse leaf which failed to mature normally and refused to cure a good colour. In view of this fact, these varieties are regarded as being unsuitable for cultivation in this State. As field mould has seldom proved to be serious here, the supposed resistance of these varieties to this disease does not make up for their lack of quality under our conditions.

"Harrow Velvet" being a burley variety suitable for air curing, cannot be compared with the flue cured varieties. It is interesting to note, however, that it produced a moderate crop of leaf which, when cured, developed fairly typical burley aroma and smoking qualities. It is understood that there might be a definite, though limited, market in Australia for good quality burley leaf. As it appears to be particularly susceptible to the ravages of downy mildew it is unlikely that it can be grown successfully in the Eastern States where field infection is much more serious than it is here, so that any development of this type of tobacco is most likely to take place in W.A.

There was no significant difference in total yield of leaf between the remaining eight varieties.

Grading was carried out during the second week in July, and as the suitability of any variety depends not only on total yield, but on leaf quality also, the value of the marketable leaf was estimated according to commercial standards. The estimated value of the graded leaf was then used as a basis for calculating

results. It was found that the variability of values between individual plots of the same variety was great, this probably being due in great measure to the unfavourable weather experienced during January and February. This variability may have obscured the results of the trial, but it can be said that the new varieties "Gold Dollar," "Yellow Mammoth," "White Mammoth" and "No. 35 White Stem Orinoco" all showed definite promise and appeared to be capable of giving satisfactory yields of high quality leaf. Of these, the two latter were the best varieties, but all will be subjected to further trial during the forthcoming season.

Samples of leaf of all varieties were submitted to the Council for Scientific and Industrial Research and to three firms of tobacco manufacturers for smoking tests. At the time of writing one report has been received from an Eastern States' firm which gives the following opinions:—

"Hickory Pryor" is a good *tobacco* type, burning very slow.

"Bonanza," a good *cigarette* type with good smoking qualities, bad burning.

"Yellow Mammoth" and "White Mammoth," good *cigarette* types with good smoking qualities but very slow burning.

"Gold Dollar," "Cash" and "White Stem Orinoco," good smoking qualities, burning slow.

"Kelly" is not very attractive.

Minor Element Experiment.

Object. To study the effect on growth and quality of leaf of:—

(a) Various minor elements when added singly to the control fertiliser.

(b) Various minor elements when added jointly to the control fertiliser.

(c) To test the possibiltiy of reducing the amount of control fertiliser by the addition of a complete dressing of minor elements.

The experiment consisting of 10 treatments was arranged in the form of a randomised block with four separately randomised replications of each treatment. Treatment rows consisted of 20 plants spaced at 2 ft. intervals, the rows being 4 ft. apart. Half of each row was planted on green-manured land and half on weed fallow. The variety planted was "Hickory Pryor."

The treatments were as follows:—

1. (Control). Standard tobacco fertiliser, 1,000 lbs. per acre.
2. Control plus sulphate of iron at 20 lbs. per acre.
3. Control plus magnesium sulphate at 20 lbs. per acre.
4. Control plus copper sulphate at 20 lbs. per acre.
5. Control plus zinc sulphate at 20 lbs. per acre.
6. Control plus manganese sulphate at 20 lbs. per acre.
7. Control plus cobalt chloride at 5 lbs. per acre.
8. Control plus borax at 5 lbs. per acre.
9. Control plus complete mixture of above "minors."
10. Half the amount of control fertiliser plus complete mixture of "minors."

The fertiliser was applied in the furrow about four inches deep, and the plants were set out on the 4th of November. By the 16th of November all plots were looking well except Treatments 7 and 8 (cobalt and boron) which were rather backward in coming away. By the beginning of December, Treatment 5 (zinc) was definitely ahead of all others on all four blocks, while Treatments 7 and 8 were still most backward. Little or no difference could be observed between the other treatments at this stage. By the 10th of January, the plots treated

with magnesium (Treatment 3) appeared to have made the best growth, while Treatment 5 (zinc) was no longer outstanding. At this stage the cobalt and boron treatments appeared to have recovered from their initial setback and were as well grown as the controls.

It was noteworthy that Treatment 10 (half control plus complete mixture of "minors") had made at least as good growth as the controls, and there was no apparent difference between Treatments 9 and 10, both of which received a complete mixture of "minors."

Analysis of the total yields of cured leaf obtained showed no significant difference between treatments. This indicates that the application of only 500 lbs. per acre of standard tobacco fertiliser plus the complete mixture of "minors" was as good as 1,000 lbs. per acre of standard tobacco fertiliser alone.

Unfortunately, owing to the limited area of land available for this experiment no direct comparison was made between 500 lbs. and 1,000 lbs. per acre of standard tobacco fertiliser (Treatment 1), but an analysis of the leaf value showed that the latter was only exceeded by 1,000 lbs. of standard mixture plus all "minors" (9), while neither differed from 500 lbs. of standard mixture plus all "minors" (10).

The fact that all "minors" except boron, zinc, and manganese had a depressing effect on leaf value, when added singly to the standard mixture, may indicate the cause of the response to (9) and (10), but this is by no means certain.

There is no doubt that the weather conditions experienced just before harvesting commenced, adversely affected the results of this experiment, but in view of the important indications obtained the experiment is being continued on a more elaborate scale this season.

Samples of leaf from all treatments were submitted to the C.S.I.R. and to three firms of tobacco manufacturers for smoking tests. To date one report has been received from an Eastern States firm which states that there is no detectable difference between the various samples, and that, so far as smoking quality is concerned, the use or otherwise of "minor" elements, with or without a reduction in the application of tobacco fertiliser is purely a matter of economics.

Organic Nitrogen Experiment.

Object. To determine whether replacing the sulphate of ammonia fraction of inorganic nitrogen in standard tobacco fertiliser with organic sources of nitrogen is of advantage to the tobacco crop.

The sources of organic nitrogen were (a) fish manure, (b) dried blood, (c) stable manure, and the amounts used to replace the sulphate of ammonia contained respectively equivalent quantities of nitrogen.

The experiment consisted of four treatments with four separately randomised replications, and it was planted on the 4th of November with plants of the "Kelly" variety.

There was no obvious difference between treatments during growth, and analysis both on the basis of total yield and of leaf value, showed no significant differences. This confirms the results obtained from the four previous trials, and it can be assumed that no advantage is obtained by substituting any of the above sources of organic nitrogen for the inorganic sulphate of ammonia contained in the standard tobacco fertiliser used in this State. A large number of smoking tests have been carried out by the C.S.I.R. on samples of leaf obtained from this experiment over four successive years, and these also have shown no effect of treatment so far as smoking quality is concerned.

Potash Experiment.

Object.—To determine the effect of different rates of application of potash on the yield and quality of tobacco leaf.

The rates of potash used were as follows:—

Treatment 1. As in standard tobacco fertiliser at 1,000 lbs. per acre (= 120 lbs. sulphate of potash).

Treatment 2. Potash increased by 100 per cent.

Treatment 3. Potash reduced by 50 per cent.

Treatment 4. No potash.

The experiment was arranged in the form of a randomised block with four separately randomised replications, and was planted on the 14th of November, the "Gold Dollar" variety being used.

There was no obvious difference between treatments during growth and ripening, but analysis of the total weights of leaf obtained showed that Treatment 2 (increased potash) was better than Treatments 3 and 4 (reduced potash and no potash respectively), but did not differ significantly from Treatment 1. This indicates that the use of potash is beneficial and that the most effective level is between 120 lbs. and 240 lbs. of sulphate of potash per acre.

This experiment has now been carried out over a period of five years and during this time numerous samples of leaf have been tested for smoking quality by the C.S.I.R.; however, no significant differences between treatments have as yet been detected.

Superphosphate Experiment.

Object. To determine the effect of different rates of application of superphosphate on the yield and quality of tobacco leaf.

The rates of superphosphate used were:—

(a) As in standard tobacco fertiliser at 1,000 lbs. per acre (= 700 lbs. super per acre).

(b) Super increased by 50 per cent.

(c) Super reduced by 50 per cent.

This experiment has also been carried out over a period of five years, and this year it consisted of three treatments with four separately randomised replications. Planting was carried out on the 7th of November with the "Yellow Mammoth" variety. Analysis shows no effect of treatment.

Damage was done to some of the plots by rabbits shortly after planting and this, together with the unfavourable weather experienced just before harvesting caused great variations in yield and value as between the replications; these factors may thus have obscured any results separable under normal conditions. The results obtained in previous seasons, however, have indicated that a reduction in the application of superphosphate has caused a lowering in both yield and quality of leaf.

Inorganic Nitrogen Experiment.

Object. To determine whether it is better to supply nitrogen to tobacco plants in the form or nitrate of soda or sulphate of ammonia.

This experiment has been carried out over a period of three years and this year it consisted of three treatments with four separately randomised replications. Planting was carried out on the 7th November, the variety used being "Yellow Mammoth."

Rabbits destroyed a number of plants in this experiment also, and the results obtained were therefore not regarded as reliable. The results of previous seasons' experiments, however, have indicated that a mixture of nitrate of soda and sulphate of ammonia as supplied in the standard tobacco fertiliser gives more satisfactory results than does the same amount of nitrogen supplied wholly in either one of these forms.

ACKNOWLEDGMENTS.

The authors are greatly indebted to Mr. S. L. Kessell (Conservator of Forests) for making available the services of his Statistical Branch for the purpose of assisting with the statistical analysis of the results.

A Record of a New Noxious Weed, and a Warning to Farmers and Settlers.

RAPISTRUM WEED.

(Rapistrum rugosum (L.) All.)*

C. A. Gardner.

A specimen recently received from Nangetty Station, near Mingenew, has been identified as *Rapistrum rugosum* (L.) All. This plant, now recorded as a new addition to the naturalised flora of Western Australia, belongs to the Cruciferae, and adds still another of the undesirable plants of this family which provides so many of our serious weeds that from time to time are introduced into this country, and which find here conditions favourable for their spread. This plant, here illustrated for the information of farmers and settlers, is, as far as we know at present, confined to two areas—Nangetty Station and the adjacent roadsides, and Marchagee Station on the Midland Railway. That it has been present in the former locality for some years is evident; that it is spreading is also evident, and it is to be hoped that a careful watch will be maintained so that remedial measures promptly undertaken, may result in this pest being controlled and ultimately destroyed before it has an opportunity to spread.

We are most of us familiar with the history of the spread of the wild turnip in Western Australia, which, as one of the most serious weeds of wheatfields, has caused considerable losses and hardships, and of which the rapidity of spread is unequalled by any other introduced weed. The wild turnip was originally introduced into the Nangeenan district about the year 1914, but it was not until 1925 that it caused any concern, and from the latter date its spread has been such that it has invaded practically the entire wheatlands of Western Australia.

It is a well known fact that many weeds after introduction into a new land may develop very slowly for several years, perhaps becoming acclimatised, and then quite suddenly and unexpectedly assume seriously aggressive habits, and spread alarmingly. Saint John's Wort is an example in Victoria, and the Wild Turnip

*Derived from rapum, the Latin name of the turnip; rugosus, wrinkled, referring to the roughened seed vessels.

and Cape Tulip are excellent local examples. Rapistrum weed has already been here for at least twelve years, and it was not until this year (1939) that, probably due to very favourable conditions for the germination of its seeds, it spread at Nangetty from an area of a few acres to almost five hundred. From its original place of establishment—the Nangetty sheep yards—it has spread over this area, and is now along the roadsides for about ten miles towards Mingenew, occurring it is true in a sporadic fashion, but even next year it may develop gregariously. And it is this occurrence along the roadsides that should give cause for concern; it has evidently been deposited there by travelling sheep, and it is from roadsides that it can most readily invade cultivated land, and also be still further carried by travelling stock to other districts. The call for action on the roads is therefore urgent. The other centre of infestation—the railway yard at Marchagee—is one from which one might expect the seeds to be readily carried into the district. These two localities are given so that farmers nearby may be on the watch for the plant.

Rapistrum weed is already naturalised in Victoria and South Australia, where it is spoken of as the "Wild turnip—a bad weed of wheatfields." The name "Wild turnip" of course cannot be applied to the plant here, since it is already given to *Brassica Tournefortii*. The reputation which Rapistrum has in other places would be equally true for Western Australia should the weed spread to any extent, for it combines the undesirable features of both the wild radish and the wild turnip. Most of its seeds are, like those of the wild radish, enclosed in seed-vessels that do not liberate their seeds, and thus, especially when buried by cultivation, retain their powers of germination for several years. On the other hand it has the tall stature, the free seeding habit, and the somewhat brittle stem bases of the wild turnip, and wind may be an important factor influencing its spread.

Rapistrum rugosum is a Noxious Weed for the State of Western Australia by Government Proclamation, and as such it is the duty of all concerned to destroy the plants wherever they are found. The local authority (the Road Board) is responsible for the enforcement of the Noxious Weeds Act in its district, and a closer co-operation between farmers and the local authority is desirable in the interests of the farming community.

As with all annual weeds, the essential feature of control is the prevention of seed formation, hence it is necessary that plants should be destroyed before flowering has advanced. Any action taken afterwards is useless. Plants on roadsides may be destroyed by pulling or grubbing at least earlier than the full flowering period, and destruction by burning; plants in arable land may be destroyed in a similar manner, or, when too numerous for individual treatment may be cultivated, or kept in check while young by a sufficiently heavy grazing by sheep which will eat the plants with avidity in the young stages of growth.

Description of plant.

Annual; stems erect, 1-2 metres (3-6 feet) high, branching from the base or rarely simple, much branched upwards, the branches ± flexuose, erect or spreading, the stems hard and wiry when mature, and usually weakening at the base at seeding time, hispid when young, but becoming glabrous and violet-coloured with age. Basal leaves clustered, petiolate, lyrate-pinnatisect with 2-4 pairs of lobes usually unequal, the terminal lobe the largest, suborbicular to ovate or obovate, shortly and coarsely toothed, obtuse; lateral lobes oblong-ovate, obtuse, with a few teeth, the lowest much smaller, triangular, subentire; upper leaves subsessile, entire or minutely toothed, ± hispid. Racemes at the time of flowering dense, becoming elongated in fruit, 30-150-flowered; pedicels filiform, glabrous. Sepals erect

spreading, 4-5 mm. long, the outer linear, the inner oblong, hispid, especially towards the apices; petals yellow, obovate, clawed, obtuse or truncate, faintly violet-nerved; stamens 6; pistil cylindrical, biarticulate, the lower article 1 mm. long with one pendulous ovule (rarely 2 or 3); the upper article with one (rarely more) erect ovule; both articles densely hirsute; styles glabrous; stigma broad. Fruiting pedicels erect, almost appressed, 2-6 mm. long. Fruit biarticulate, 8-10 mm. long, the lower article 2.5-3 mm. long, oblong, terete, 1.5 mm. diameter, slightly

RAPISTRUM WEED

ribbed, tardily dehiscing by two valves, normally one-seeded, very rarely slender and 2-3-seeded. Upper article much broader, globular, 3-5 mm. diameter, longitudinally ribbed, 1-seeded, indehiscent, terminating in a short or long beak which is rarely deficient with age. Seed in the lower article pendulous, ovoid or oblong-cylindrical; seed in the upper article erect, ovoid, usually larger than the seed of the lower article, yellowish-brown, smooth and shining.

Flowering August-November; fruiting September-December. Original home Europe. Naturalised in Germany, Southern France, Italy, Spain, North Syria, Madeira, Teneriffe, South America, Australia.

RAPISTRUM WEED.

(Rapistrum rugosum (L.) All.)

EXPLANATION OF PLATE:

A, basal portion of young plant. *B*, leaf (less than natural size) from the basal cluster. *C*, portion of inflorescence showing lengthening, with flowers at the apices; young fruits, and mature fruits towards the base. *D*, flower (enlarged). *E*, flower with the petals removed. *F*, gynœcium. *G*, fruits. *H*, section through much enlarged fruit showing the two articles—the upper globular article with erect seed, the lower with smaller pendulous seed, and the point of disarticulation. *J*, transverse section of the upper article of the fruit. *K*, seed (much enlarged).

—*Original drawing. Ninghan, near Mingenew. November*, 1939.

Brown Spot, a Serious Disease of the Passion Vine.

W. P. Cass Smith, Plant Pathologist.

The common passion vine (passiflora edulis) has been grown in Western Australia for many years, but the acreage under cultivation has only increased slowly; according to the best available information the area under crop for the 1938-39 season, was approximately 100 acres.

A lack of suitable soil types or congenial climatic conditions is certainly not responsible for this slow expansion in area for on a small scale the passion vine is successfully grown in many widely separated districts throughout the lower South-West portion of the State.

Undoubtedly this position is very largely due to two main factors, firstly marketing difficulties which make the disposal of commercial crops a rather uncertain matter, and secondly diseases, which during recent years by seriously reducing the productivity of many vines have had an important bearing on the acreage cropped.

In November this year an opportunity occurred for the writer to visit North Dandalup, Keysbrook, and other major passion vine growing areas, and during this inspection a serious disease was noticed which symptomatically appeared to be identical with Brown Spot as described by Simmonds. (1) Isolations made subsequently from infected leaves and stems confirmed this diagnosis.*

The following information compiled from observations made by the writer and by various members of the Horticultural Branch and also from experiments conducted elsewhere is briefly recorded, with the hope that it may be of advantage to growers, many of whom are extremely puzzled by this disease.

Symptoms and Effects.

Brown Spot may attack all the above-ground parts of the vine. On the leaves infection first becomes evident by the appearance of small brown spots which under favourable conditions enlarge in a more or less circular manner, gradually developing lighter coloured central areas. (Plate 1.) The spots may enlarge until they are from one quarter to half an inch in diameter or occasionally larger, and from one to several spots may occur on a single leaf.

After infection the leaves usually become paler, and fall very readily.

On the branches, dark brown lesions appear which gradually elongate to a length of one to several inches, and frequently during elongation they extend in width till the branch is completely encircled. (See arrow, plate 2.)

When this occurs the sap flow is obstructed, causing the death of all distal portions of the branch. The sudden wilting of fruits (Plates 2 and 3) on a recently cinctured branch, is an obvious symptom by which the disease can often

*Opportunity has not yet occurred to prove pathogenicity by artificial inoculation, but the species of Alternaria isolated shows sufficient agreement in cultural characters with those described by Simmonds (1) and (2) for the writer to be certain that it is the pathogen.

Brown Spot of the Passion Vine has not previously been described from this State but in all probability it has been present for several years; "Anthracnose" caused by Gloeosporium fructigenum was recorded in 1936 (3).

Although "Anthracnose" may occur here as a separate disease, it has not yet been noticed by the author; Gloeosporium sp. are however frequently associated with the older parts of Brown Spot stem lesions, but not invariably so.

The control measures previously recommended for "Anthracnose" were quite applicable for Brown Spot and when fully adopted they have given excellent results.

be detected in vines which may otherwise appear quite healthy; in many cases the affected branch must be traced back several feet before the causal lesion is discovered.

It is also noticeable that the leaves on such a branch remain fresh and green for some time after wilting of the fruit commences.

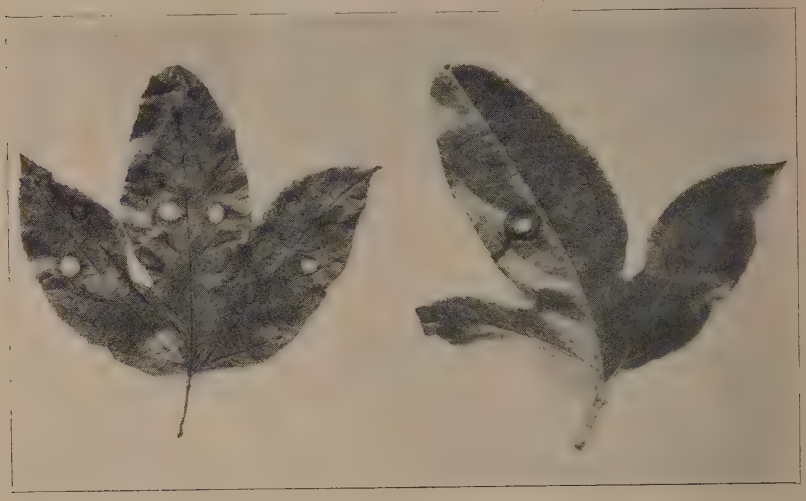


Plate I.
Passion vine leaves infected with Brown Spot (*Alternaria passifloroe*).
[*Photo. by Govt. Photographer.*]

Brown Spot may also attack fruit producing brownish spots which as they enlarge gradually become depressed and more or less circular in outline. (Plate IV.)

Fruit is frequently infected on the cheek but it may also be attacked at the stalk end, or at any other point.

It will be seen therefore that the productivity of the vines is seriously lowered by the disease, for not only may fruit be attacked directly, but through causing defoliation and dieback of branches, the vigour of the vine is so depleted that the crop is considerably reduced.

When vines are badly attacked by Brown Spot, almost total defoliation may occur, and tangled masses of dead stems are noticed. In such cases the effect may be so severe that the vines ultimately die.

Cause of the Disease.

Brown Spot is caused by the fungus *Alternaria passiflorœ*, and it is spread by means of fungal seeds or spores which are produced abundantly from the surface of any diseased parts; spore production may continue for long periods after the affected parts are killed.

The spores are carried by wind, or splashed by rain, and by these means some will eventually lodge on other healthy vine parts, where in the presence of moisture and with sufficient temperature they germinate and cause new infections.

Factors Affecting the Spread of the Disease.

Pruning.

Of all factors affecting the disease, pruning is by far the most important. Where pruning is systematically carried out as an annual procedure the occurrence of the disease is noticeably reduced, even in the absence of any other control

Plate II.

Passion vine branch recently cinctured by the Brown Spot fungus (at point indicated by arrow). Death of all distal portions of the branch will ultimately occur.

[*Photo. by Govt. Photographer.*]

measure. When the vines remain unpruned, they gradually develop into an impenetrable mass of foliage and runners and in this condition any diseased parts remain in close contact with still healthy parts; furthermore, light and air are excluded, and in consequence the tangled growth remains wet for long periods after rain, thus providing ideal conditions for the spread of the disease.

For this reason it is readily observed on most properties where pruning has been neglected, that the youngest vines with relatively sparse foliage are comparatively healthy, whereas in older vines with more profuse growth, the disease is more widespread.

Judicious pruning stimulates the vine to healthy vigorous growth and greatly increases its productive life; it also enables all diseased parts to be removed and burned during the process, thus destroying the sources of infection.

Plate III.

Wilting of fruit on a cinctured branch is a symptom by which Brown Spot can frequently be easily detected. The affected branch may have to be traced back several feet before the causal lesion is discovered.

[*Photo. by Author.*]

Furthermore, air and light can penetrate to all parts of the pruned vine, which allows the foliage to dry quicker after rain, thus preventing the germination of the fungal spores.

The time of pruning will vary with local conditions, and with the kind of [illegible] and North Dandalup districts, it is the custom of the leading growers to prune

early in March, after the main summer crop is harvested. By so doing a late winter and intermediate crop is also obtained which varies in yield with the season and with the character of the previous summer crop.

When a heavy winter crop is desired, pruning is delayed until the summer crop is about half grown.

Climatic Conditions.

Brown Spot is favoured by warm moist weather, and so in normal seasons the disease is most serious during the Spring and early Summer months.

Although as yet there has been little opportunity to study accurately the seasonal incidence of the disease, observations indicate that Brown Spot, though

Plate IV.
Fruit Attacked by Brown Spot.
[*Photo. by Govt. Photographer.*]

present during winter, does not usually become very active at this stage as the temperatures are low; from August to December, especially with high rainfall it may gradually increase in seriousness and spread very rapidly.

Unless unseasonable summer rains subsequently occur, the weather then becomes hot and dry, and in consequence the spread of the disease is limited until the Autumn rains commence.

Spraying.

Where systematic pruning is carried out annually, applications of a suitable fungicidal spray will effectively control this disease. It should be remembered however that the main purpose of the spray is to cover still healthy parts in order to prevent the disease from spreading, and that unless the vines are kept well pruned this object cannot be achieved and spraying is therefore ineffective.

Of all the common fungicides, home-made Bordeaux Mixture, plus a suitable spreader, has given the best control, and where the disease is present the cost of spraying will be repaid many times over.

Care should be taken to apply the spray on a fine day when it will dry quickly otherwise severe burning may be caused.

Control.

(1) Train the passion vine systematically from the commencement of growth, keeping the main runners well tied to their respective trellis wires, in order subsequently to facilitate pruning.

(2) Prune the vines well back at least once a year at a time determined according to whether a summer, intermediate or winter crop is desired.

The more freely light and air can penetrate through the vines within limits, the less serious will the disease be. All diseased lesions should be cut out during this operation, and all prunings should be burned as quickly as possible.

(3) Spray the vines after pruning with home-made Bordeaux Mixture 4: 4: 40 strength + a suitable spreader. (See Leaflet 314 which is free on application to the Department of Agriculture.)

Repeat the spraying at monthly intervals during the spring and early summer months, and thereafter at two monthly intervals if required by the season. When mature fruit are are on the vine, ammoniacal copper carbonate may be substituted for the Bordeaux Mixture in order to avoid discolouration.

(4) Periodically examine all vines to detect any newly formed lesions and destroy them before they become a source of infection to other shoots or vines.

(5) Artificial waterings, if any, should be reduced to a minimum, and in home gardens overhead watering should be discouraged.

Acknowledgment.

The author gratefully acknowledges the assistance he has received in connection with this disease from investigations carried out in Queensland, which have been reported from time to time in the Queensland Journal of Agriculture, by J. H. Simmonds, M.Sc.

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Associations for the Improvement of Dairy Herds in Western Australia.

REPORT FOR YEAR ENDING 30th APRIL, 1939.

G. K. BARON-HAY, Superintendent of Dairying, and G. SLATER.

The season commencing May, 1938, was a favourable one for the production of dairy produce, the usual autumn rains being regular without extremes of monthly rainfall or temperatures.

More applications were received for the formation of new Units than could be approved and commenced with the funds which were available, but it was possible to commence six new Units at Bridgetown, Metricup, Ruabon, Northcliffe, Cowaramup, and Narrogin respectively.

The average production of those cows under test in the scheme is shown in Table 1 below and includes the productions of all cows which were under test for three months or more.

TABLE 1.

AVERAGE PRODUCTION PER COW.

No. of Herds.	No. of Cows.	Milk.	Test.	Butter Fat.
		gals.	%	lbs.
485	12,368	487	4·48	218·7

This average production of butter fat is approximately the same as for the previous year 1937-38, showing a reduction of only 4 lbs. per cow. In view of the inclusion of the six new Units with an average production of 193 lbs. butter fat per cow, this average production is considered satisfactory.

That the maintenance of this production is not entirely due to seasonal conditions is shown by the steady improvement each year since grade herd recording was initiated in 1933-34 as is seen in the following Table 2, which indicates clearly that testing is a great factor in rapidly effecting improvement in low producing herds and assisting the farmer in maintaining these increased yields.

TABLE 2.

AVERAGE PRODUCTION PER COW, 1934–1939.

Year.	No. of Cows.	Milk.	Test.	Butter Fat.
		gals.	%	lbs.
1933-34	4,038	415	4·35	180·6
1934-35	4,088	456	4·56	207·8
1935-36*	4,590	459	4·51	207·3
1936-37†	9,115	434	4·53	196·7
1937-38*	10,033	486	4·59	223·1
1938-39‡	12,368	487	4·48	218·7

* 1 new unit. † 9 new units. ‡ 6 new units.

It is interesting to note that, as in previous years, the average production of herds upon their entry into the herd recording scheme is below 200 lbs. of butter fat per cow, which is considered the minimum for profitable and safe butter fat production, but it is confidently anticipated that the six new Units which averaged 193 lbs. butter fat per cow will have exceeded the minimum safe production by the end of the next testing year and should continue to increase thereafter.

Because of the regularity with which cows in new Units average between 180 and 190 lbs. butter fat per cow over a number of years, it appears that this figure may be taken as a reliable estimate of the average production of dairy herds outside the scheme.

Production per Cow in each Unit.

The average production per cow in each Unit is shown below in Table 3:—

TABLE 3.

Unit.	No. of Herds.	No. of Cows.	Percentage of Heifers.	Milk.	Test.	Butter Fat.	
						1938–39.	1937–38.
				lbs.	%	lbs.	lbs.
A. Donnybrook ...	29	628	16	4,769	4·83	230·10	275·18
B. Serpentine	16	335	14	5,452	4·34	236·90	236·93
C. Cookernup	21	750	25	5,599	4·50	252·05	230·83
D. Harvey	20	489	19	5,355	4·56	244·42	219·69
E. Brunswick	21	654	20	5,967	4·76	284·37	253·15
F. Dardanup	24	768	11	4,832	4·49	216·94	192·98
G. Capel	18	679	14	5,166	4·30	222·18	222·66
H. Balingup	25	760	16	5,572	4·71	262·10	243·06
I. Forest Grove ...	22	433	14	5,152	4·66	240·58	211·82
J. Pemberton ...	19	308	12	5,156	4·74	244·76	204·49
K. Rosa Brook ...	25	548	19	4,668	4·74	221·57	224·33
L. Vasse	18	461	8	4,090	4·36	171·91	229·59
M. Manjimup	25	579	11	4,614	4·53	209·19	214·28
O. Benger	19	551	11	5,332	4·38	233·67	233·25
P. Coolup-Pinjarra ...	20	551	8	4,271	4·63	218·20	210·01
Q. Greenbushes ...	22	485	16	4,530	4·90	222·19	217·35
S. Albany	20	402	23	4,595	4·28	196·83	185·46
T. Bridgetown ...	22	657	13	4,183	4·41	184·76	...
U. Metricup	22	490	23	5,048	4·95	250·36	...
V. Ruabon	20	564	11	4,240	4·46	188·97	...
W. Northcliffe	25	552	15	4,078	4·43	180·89	...
X. Cowaramup ...	19	442	16	4,245	4·60	195·45	...
Y. Narrogin	13	282	30	3,766	4·36	164·04	...

It will be seen that of the 23 Units embracing over 12,000 cows under test, no less than 16 averaged over 200 lbs. butter fat per cow, the highest production being that of 284.4 lbs. butter fat per cow in the Brunswick Unit.

The great value of herd recording to dairy farmers is shown more clearly by examining the average production of six representative Units which are shown in Table 4, and briefly discussing the means by which increased productions have been obtained.

In Table 4 the average productions of the Units at Donnybrook, Cookernup, Brunswick, Dardanup, Capel and Balingup since 1933-34 are shown—

TABLE 4.

IMPROVEMENTS IN SIX REPRESENTATIVE UNITS.

Herd Testing Unit.	Butter Fat.					
	1933–34.	1934–35.	1935–36.	1936–37.	1937–38.	1938–39.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Donnybrook	219·5	266·8	265·1	235·79	275·18	230·10
Cookernup	160·4	183·5	191·9	195·23	230·83	252·05
Brunswick	169·2	206·0	217·2	231·32	253·15	284·37
Dardanup	188·6	192·2	168·2	180·73	192·98	216·94
Capel	182·9	203·1	221·1	209·96	222·66	222·18
Balingup	174·6	212·4	196·3	212·78	243·06	262·10

One feature which all these Units, except Donnybrook, have in common is that, when herd recording was commenced, the average production of cows was considerably below the 200 lb. mark which is the minimum regarded as profitable, productions ranging from 160 lbs. butter fat per cow in the Cookernup Unit to 188 lbs. per cow in the Dardanup Unit.

In the case of the Donnybrook Unit, dairy farming is combined with general mixed farming, including fruitgrowing, and the system there has been to calve cows as early as possible in the autumn so that they may be dried off in January so as not to interfere with the work of picking and packing fruit. Furthermore, the herds in this district were above the average as far as breeding is concerned and mainly of the Jersey breed.

It will be noticed that this Unit has always shown productions considerably above the economic minimum but that the productions have fluctuated up and down from year to year between 220 and 275 lbs. butter fat per cow, and it will be noticed further that in other Units the maximums which have been reached are within these same limits, except in the case of Brunswick which last year had the fine average of 284 lbs. butter fat per cow.

It is found in practice extremely difficult for whole Units embracing 500 to 700 cows to maintain an average production of 250 lbs. butter fat consistently, by reason of the extreme difficulty in obtaining pure bred bulls with a sufficiently high butter fat backing to increase yields above this figure. This difficulty is shown by reason of the fact that during 1938-39 the average production of all pure bred cows submitted for official test was approximately 292 lbs. butter fat per cow.

The steady increase in production in the Cookernup and Brunswick Units calls for special mention, the means by which this increase has been obtained being a general improvement in dairy farm husbandry, such as by increasing the number of cows calving early in the season, increasing fodder conservation, the elimination of very low producers, and by the selection of the best young stock for the replacement of inferior cows. The problem facing these Units now is to maintain the high average production which was achieved last year.

The Dardanup Unit which at present is approaching a satisfactory basis as far as production is concerned has shown disappointing results for a number of years. These productions, however, have not been due to any special inferiority in the capacity of the dairy stock, one of the causes being a very low percentage of cows calving early in autumn.

Stack silage on Mr. D. Semple's farm, Pemberton. Approximately 75 tons per annum is conserved, using labour saving devices.

During 1937-38 only 29 per cent. of the cows calved during the best time of the year. This figure was doubled during 1938-39 and is mainly responsible for the large increased production from 193 lbs. to 217 lbs. per cow.

The results achieved in the Dardanup Unit this year with 768 cows is gratifying, and it is hoped that this Unit will continue to increase its production until at least an average of 250 lbs. butter fat per cow has been achieved.

The Capel and Dardanup Units—two large Units which embrace respectively 679 and 760 cows—are Units which are seriously affected by seasonal conditions, particularly the Capel Unit.

By careful farm management a high percentage of the cows in these Units calved early in the season, and some of the farmers with the largest herds do not conserve fodder for feeding to their dairy cows, as these farmers dry off their herds early in the new year, turning the animals on to dry feed which has been reserved for this purpose until near calving. It is probable that higher productions could be obtained by lengthening the lactation period by hand-feeding, but this may be unprofitable with such large herds if the labour involved in the cutting of fodder reserves is high. This aspect of fodder conservation has not been investigated fully, although for small and medium sized herds there is little doubt that the practice of fodder conservation is extremely profitable.

Optimum Lactation Period.

As in previous years an analysis of the dates of calving of the 8,892 cows which have completed test during the year has been made with a view to correlating the time of calving with the production of cows, and the results of such analysis corroborate those for previous years; and as, since the inception of the scheme in 1933-34, approximately 50,000 cows have been under test, the information may be considered reliable.

Ensuring high autumn production by ample fodder reserves for summer and early autumn feeding. Mr. J. Littlefair's farm, Pemberton.

In the graph below it will be noticed that peak production was given by those cows calving between the end of March, April and May, with a slight reduction for cows which calved during June. Where cows calved after July, the fall in average production was rapid, the lowest production being where cows calved towards the end of September, October, and November.

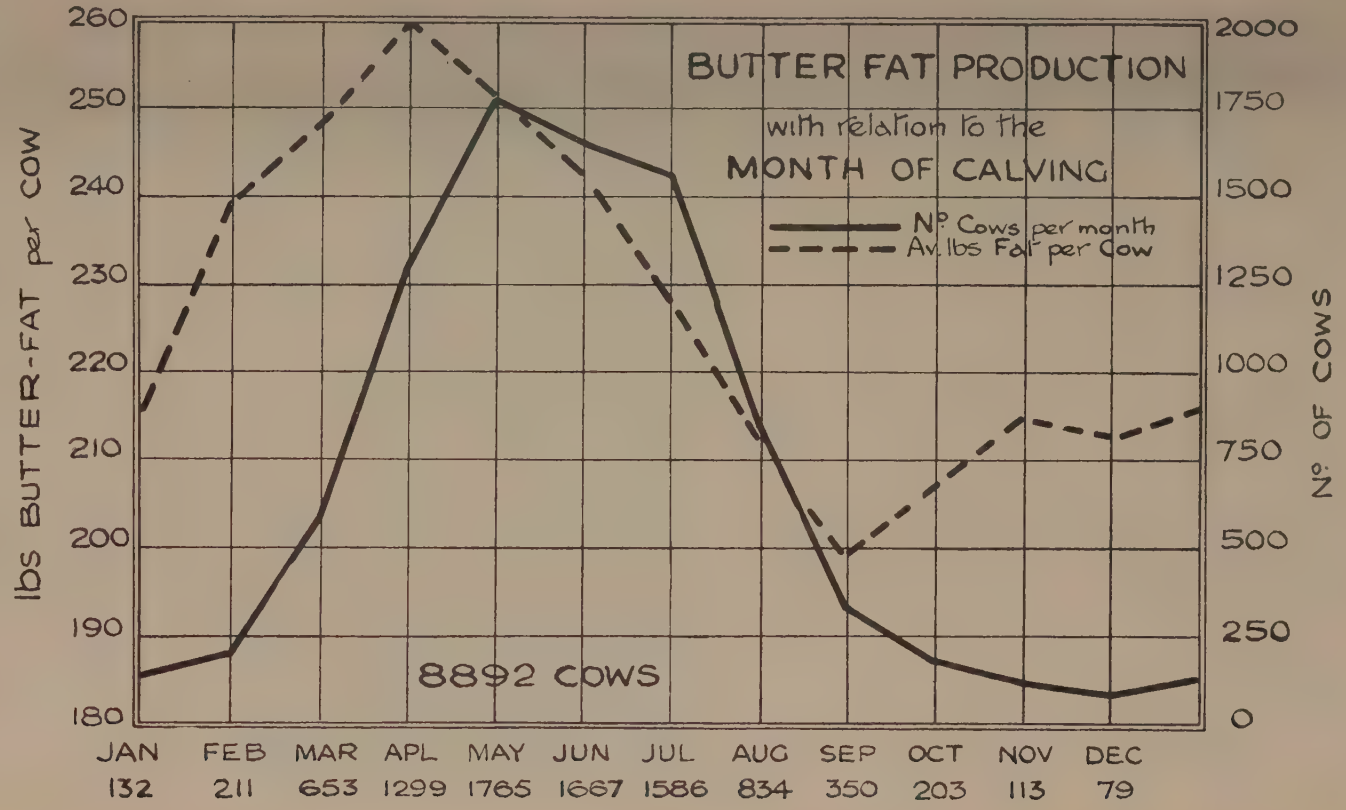
Authorities on conditions necessary for economical dairy production have stated that dairy farming can only be profitable where there is a season of at least 10 months growing period for pasture and, for this reason, it was considered doubtful if the South-West portion of Western Australia could be called dairying country. By reason, however, of developing a special system applicable to local conditions, dairy farmers are able to produce butter fat at prices comparable with those in other portions of the Commonwealth.

Two of the main practices which have been developed are—

(1) An endeavour to commence all lactations as early in autumn as possible, with the view of enabling the cows to have green pasture for a long period—approaching nine months.

(2) An ample conservation of fodder so that cows may be kept in high condition prior to the commencement of the next lactation.

These two factors combined with the generally recognised policy now of improving production along sound breeding lines has placed dairy farming on a sound footing in Western Australia.


BUTTER FAT PRODUCTION
with relation to the
MONTH OF CALVING
No. Cows per month
Av. lbs Fat per Cow
lbs BUTTER-FAT per COW
No. OF COWS
260
250
240
230
220
210
200
190
180
2000
1750
1500
1250
1000
750
500
250
0
8892 COWS
JAN FEB MAR APL MAY JUN JUL AUG SEP OCT NOV DEC
132 211 653 1299 1765 1667 1586 834 350 203 113 79

In Table 5 is shown the percentage of cows which commenced their lactation prior to July of last year, and also a comparison of the production of these cows with the average produced by all the cows in the Unit.

TABLE 5.

PERCENTAGE OF COWS COMPLETING 9 MONTHS TEST.

Unit.	Cows.	Butter Fat.	Unit Average Butter Fat.
	%	lbs.	lbs.
A. Donnybrook	86	236·54	230·10
B. Serpentine	85	250·39	236·90
C. Cookernup	74	273·31	252·05
D. Harvey	49	262·28	244·42
E. Brunswick	63	293·80	284·37
F. Dardanup	58	222·95	216·94
G. Capel	78	233·75	222·18
H. Balingup	87	264·35	262·10
I. Forest Grove	57	260·82	240·58
J. Pemberton	69	273·61	244·76
K. Rosa Brook	50	252·44	221·57
L. Vasse	63	184·60	171·91
M. Manjimup	78	219·95	209·19
O. Benger	95	235·57	233·67
P. Coolup-Pinjarra	78	235·66	218·20
Q. Greenbushes	39	269·19	222·19
S. Albany	68	216·41	196·83
T. Bridgetown	99	184·05	184·76
U. Metricup	71	281·65	250·36
V. Ruabon	53	221·55	188·97
W. Northcliffe	36	209·73	180·89
X. Cowaramup	43	276·32	195·45
Y. Narrogin	67	180·46	164·04

It is significant that the new Units generally, except that at Bridgetown, do not approach the average high percentage of cows calving in the early autumn as in those Units which have been in the scheme for a number of years.

Mr. J. Salerian's dairy at Hamel. Cows are fed in the bails in the left foreground, and pass into the milking bails through a concrete race. Hay shed holds approximately 100 tons of hay. Herd of 78 cows averaged 290 lbs. of butter fat.

Of particular interest are the results in the Dardanup Unit which, during 1937-38, only had 29 per cent. of the cows calving during the desirable portion of the year, part of which was due to outbreaks of disease causing partial sterility in the district and which is being overcome. During the following year the percentage of cows was double, namely 58 per cent., which calved during the early autumn and the average production of the Unit has increased from 193 lbs. to 217 lbs. per cow.

Herds Grouped According to Production.

In Table 6 below an indication of the general uplift which is occurring in the production of herds which have been tested for a number of years is clearly shown.

TABLE 6.

HERDS GROUPED ACCORDING TO PRODUCTION.

Year.	Butter Fat per Head (lbs.).							
	Over 400.	350–400.	300–350.	250–300.	200–250.	150–200.	100–150.	Under 100.
	%	%	%	%	%	%	%	%
1933-34 ...	...	...	1·31	3·93	20·30	53·55	18·30	2·61
1937-38 ...	·26	·77	4·07	19·34	45·29	26·46	3·55	·26
1938-39 ...	...	·40	7·40	23·30	37·50	25·20	5·80	·40

It will be noted that whereas in the first year of testing in 1933-34 nearly three-quarters of the herds under test yielded an average production of less than 200 lbs. butter fat per cow, by 1938-39 these low producing herds had been reduced to approximately 30 per cent. which, however, is still in excess of what may be regarded as satisfactory.

One of the reasons why there is still approximately one-third of the herds in the scheme with an average production of less than 200 lbs. butter fat is that a number of farmers test their herds for one year only, or possibly two years, and then withdraw from the scheme for 12 months, the argument being that—as all cows in the herd have been tested—there is no further information to be gained by testing the same cows again.

It is worth mentioning, however, that those farmers who have remained in the scheme since the inception, or who do not withdraw their herds for short periods, are those who having attained a high average production are maintaining that high level.

During last year also six new Units commenced operation and many herds in these new Units are in the low producing groups. It is hoped that these unprofitable herds will ultimately be reduced to a very low percentage.

The table shows clearly that there is a general tendency for the number of herds in the higher production groups—over 250 lbs. butter fat per cow—to be increased and that in the 250 to 300 lbs. group the percentage of herds has increased nearly sixfold and by a similar proportion in the 300-350 lbs. group since the inception of the scheme five years ago.

Cows Grouped According to Production.

In the following Table 7 the production of cows in the two aged groups of Mature and Junior cows, being those which were under three years of age at time of calving, are given according to production.

TABLE 7.

COWS GROUPED ACCORDING TO AGE AND PRODUCTION.

(All cows tested less than 90 days excluded.)

Age Class.	Groups according to Butter Fat Production (lbs.).								Total Cows.
	Over 600.	500–600.	400–500.	300–400.	200–300.	150–200.	100–150.	Less than 100.	
	%	%	%	%	%	%	%	%	
Mature	·02	·2	1·6	17·3	45·4	20·0	11·4	4·1	10,439
Junior*	...	...	·26	4·9	34·1	28·1	22·4	10·2	1,929

* Cows under 3 years at date of calving.

As would be expected, the actual production of junior cows is less than that of mature cows, and, after making due allowance for production according to age, it is found that there is approximately the same percentage of mature cows and junior cows which failed to attain 200 lbs. butter fat during their lactation period.

During the initial years of the scheme it was noted that the production of heifers, after making due allowance for age, was considerably in excess of the average production of mature cows, which indicated that the breeding policy of farmers generally, namely, the use of a pure bred bull of one breed consistently was bearing fruit.

As would be expected, however, as the average production of herds increased, there has been an increasing difficulty amongst farmers to obtain sires with a sufficiently high "butter fat backing" as to improve and even maintain the higher herd averages. This was reflected last year in the fact mentioned above that approximately the same percentage of heifers and mature cows failed to reach the minimum economic production of 200 lbs. butter fat.

During the two previous years it was noted that the percentage of heifers in herds was unusually high, being as high as 25 per cent. to 34 per cent. which tended to reduce the general average of production.

Taking the average working life of a cow as six years, the normal percentage of heifers need not exceed 17 per cent. or one heifer for every six milking cows to maintain the herd at full strength.

It is interesting to notice that, during the year 1938-39, the percentage of heifers in herds is now 16 per cent., which should mean high average production in the ensuing year should the season be normal.

Herds Grouped According to Production.

The following four tables, Nos. 8 to 11, which give the productions of leading herds grouped according to their size, yield interesting information regarding

what can be effected by adopting those methods which have proved practical and efficient in dairy husbandry.

In Table 8 are shown those herds in order of merit which produced over 295 lbs. butter fat and consist of less than 20 cows. Seventeen herds during 1938-39 produced more than 300 lbs. butter fat per cow compared with only four herds two years previously.

TABLE 8.

HIGH PRODUCING HERDS OF LESS THAN 20 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter Fat Average.
				lb.
R. L. Maidment	Capel	11	Shorthorn ...	362·50
L. Temple	Harvey	13	Jersey	345·12
O. Foan	Donnybrook	19	do.	336·81
T. Twaddle	Cookernup	17	do.	328·52
A. Clifford & Sons ...	Donnybrook	16	do.	328·35
Mrs. L. R. Barnsby ...	Pemberton	19	Guernsey ...	327·49
W. J. Burt	Cowaramup	18	Jersey	321·60
H. G. Letchford (sen.) ...	Greenbushes	15	do.	311·17
J. McEwin	Cookernup	13	do.	311·07
J. Poller	Brunswick	17	do.	305·35
D. Della	Pemberton	13	Guernsey ...	305·10
F. George	Rosa Brook	16	Jersey	305·04
R. R. Graham	Pemberton	13	Shorthorn ...	303·76
J. Sibson	Metricup	14	Jersey	303·74
H. L. Newman	Albany	19	do.	303·29
W. Watson	Bridgetown	16	do.	302·16
Proctor & Langley ...	Donnybrook	16	do.	301·26
R. Cooper	Metricup	13	Guernsey ...	297·88
M. Brennan	Balingup	19	Jersey	297·01
D. Bendotti	Pemberton	17	Guernsey ...	294·87

The following Table 9 shows an even greater improvement in the number of herds with from 20 to 40 cows exceeding 290 lbs. butter fat per cow. During 1938-39, 17 herds of this size produced over 300 lbs. butter fat per cow, whilst two years previously only five exceeded this figure.

A herd in this group which has maintained production at a high level for a number of years is that of Mr. A. Tomerini, Balingup, which during 1937-38 averaged 308 lbs. butter fat from 32 cows and, in the next year, increased this average production to 350 lbs. butter fat from 34 cows.

It is instructive to notice that throughout the herd recording scheme those herds which are achieving the highest production and maintaining the level are those which are either pure bred cows or are cows which have been bred consistently to the same breed with carefully selected bulls and are in appearance and may be regarded genetically as of reasonably pure blood.

This is the policy advocated in all those countries where the high production per cow is of importance in the dairying industry, and it is believed that the nearer the herd approaches any one pure breed of the dairy types the higher will be the average production, and that with a crossbred herd, although high production may be obtained for one or two years, there is extreme difficulty and quite an element of luck in maintaining that high yield.

TABLE 9.

HIGH PRODUCING HERDS OF 20–40 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter Fat Average.
				lb.
A. Tomerini	Balingup	34	Jersey	352·15
S. Bowers	Brunswick	31	do.	351·10
L. A. House	Pinjarra	20	do.	339·20
C. P. House	Capel	30	Shorthorn ...	337·80
A. Miller	Cowaramup	24	Jersey	332·17
A. F. Clifton & Co. ...	Brunswick	26	do.	326·66
R. Hutchinson	do.	25	do.	323·29
R. A. Clarke	do.	38	do.	321·84
G. B. Omodei	Pemberton	24	Guernsey ...	319·96
J. Hartley	Brunswick	29	Jersey	317·79
W. Blaikie	Cowaramup	25	do.	315·44
Ellis Bros.	Brunswick	34	Shorthorn ...	311·95
L. Westcott	Serpentine	21	do.	307·56
W. J. Sears	Donnybrook	25	Jersey	307·49
F. G. Williams	Pinjarra	27	Jersey x Friesian	306·83
Mrs. H. K. Ellis	Balingup	29	Jersey	306·57
A. M. Brazier	do.	30	Shorthorn ...	301·40
L. C. Williams	Cookernup	30	do.	299·10
C. Gilmour	Dardanup	31	Jersey	293·25
Bell Bros.	Brunswick	23	Friesian	289·35

The following Table 10 gives a list of those herds of from 41 to 60 cows producing more than 257 lbs. butter fat per cow. During 1937-38 no herds in this group produced over 300 lbs. butter fat per cow and only seven herds exceeded 250 lbs., whereas, during the year 1938-39 just completed, three herds produced over 300 lbs. butter fat and ten produced over 257 lbs. butter fat per cow.

TABLE 10.

HIGH PRODUCING HERDS OF 41–60 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter Fat Average.
				lbs.
S. C. Maidment	Balingup	41	Jersey	332·55
Mrs. D. B. Rose	Brunswick	50	do.	317·75
D. Scott	Balingup	57	do.	311·26
T. Jamieson	Capel	52	Shorthorn ...	294·85
A. S. Warburton	Brunswick	49	do.	294·22
T. Stanley	Benger	43	do.	279·10
G. Dempster	do.	59	do.	276·79
K. H. Clifton	Dardanup	44	Jersey x Guernsey	267·83
W. Noakes	Brunswick	42	Shorthorn ...	262·80
G. E. White	Balingup	52	Jersey	257·41

In large herds, particularly those being conducted on commercial lines, it is difficult to attain and maintain high average yields.

The production of the herd owned by Mrs. D. B. Rose in the Brunswick Unit is instructive as showing the results which may be obtained by the consistent use

of information supplied from the scheme and also the value of testing each year, although average productions may appear satisfactory.

The following figures indicate the increase in production during the four years that this herd has been under test:—

Year.	No. of Cows.	Average Butter Fat.	Total Butter Fat.
		lbs.	lbs.
1935-36	70	185·1	12,957
1936-37	62	210·8	13,072
1937-38	51	293·9	14,991
1938 39	50	317·8	15.890

It will be seen that the average butter fat production of the herd has been raised by approximately 78 per cent. during these four years, and that during last year—when 20 less cows were being milked—the total butter fat produced was 2,933 lbs. valued at £183 in excess of that given during the first year of testing.

The herd owned by Mr. S. C. Maidment, Balingup, also deserves special notice, as this herd was increased from 29 to 41 cows between the year 1937-38 and 1938-39, while at the same time the average production was increased from 313 lbs. to 332 lbs. butter fat per cow.

The following Table 11 shows the production of herds with more than 60 cows which exceeded 240 lbs. butter fat per cow.

The leading herd—that of Messrs. Lieper and Dempster—with 62 cows has only been under test for one year with the high average production of 333 lbs. butter fat per cow. It is believed that only by continuous testing can this high average production be maintained, particularly as the herd has been increased in number rapidly by means of purchased cows.

The herd owned by Mr. J. Salerian is an example of increasing and maintaining production by careful management and breeding. This herd was increased from 66 to 78 cows in 1938-39, while at the same time the average production was increased from 266 to 290 lbs. butter fat per cow. This herd while containing only a few pure bred Jerseys is being consistently "graded up" with Jersey bulls of high "butter fat backing," and, because of the uniformity of type of the cows in the herd and the policy of breeding, these high production yields may be maintained.

TABLE 11.

HIGH PRODUCING HERDS OF OVER 60 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter Fat Average.
				lbs.
Leiper & Dempster ...	Metricup	62	Jersey	333·20
J. Salerian	Cookernup	78	do.	289·55
P. Fitzpatrick	do.	69	Shorthorn ...	280·38
Mrs. U. Eastcott	do.	64	Jersey	245·21
J. Neil	do.	78	Shorthorn ...	242·72

Each year a list of 20 leading cows in the scheme is published in the form shown in Table 12 below, and the average production of these cows shows a progressive rise each year.

This is the first year during which the production of an individual cow has exceeded 700 lbs. of butter fat for the lactation period, while two cows have exceeded 600 lbs. butter fat, 10 cows have exceeded 500 lbs. butter fat, and only three cows produced less than 400 lbs. butter fat per cow.

The yields of the Jersey cow "Belle" owned by Mr. C. Piggott, Brunswick, are outstanding. In 1937-38 this cow produced 641 lbs. butter fat during the year, and calved normally in 1938-39 and produced 705 lbs. butter fat. It is interesting to note that this cow is a pure bred Jersey bred on the estate of the late P. Rose, Balingup, but was sold as a cow culled for type and without a pedigree to Mr. Piggott at the ruling rate for grade cows.

TABLE 12.

HIGHEST PRODUCING COW IN EACH UNIT.

Owner.	Unit.	Name of Cow.	Tattoo.	Breed.	Test.	Butter Fat.
					%	lbs.
C. Piggott	Brunswick	Belle ...	EQ 1	Jersey ...	5·06	705·00
T. Jamieson	Capel ...	Moana ...	GS 59	Shorthorn x Jersey	5·83	688·95
F. Byrd	Harvey ...	Chrissie ...	DT 518	Friesian x	4·52	671·96
W. Darnell	Rosa Brook	Dolly ...	IU 14	Guernsey ...	4·88	550·05
D. Della	Pemberton	Tiger ...	JN 5	Guernsey x Jersey	5·20	545·67
O. Foan	Donnybrook	Poppy ...	AL 20	Jersey ...	5·55	540·39
G. H. Dixon	Bridgetown	Daisy ...	TK 17	do. ...	5·34	534·41
L. C. Winduss ...	Cookernup	Jossie ...	CB 6	Shorthorn x Jersey	5·27	534·03
L. A. House	Pinjarra ...	Nigger ...	PL 17	Jersey x Shorthorn	4·80	511·26
Lieper & Dempster ...	Metricup ...	Bonnie ...	US 6	Shorthorn ...	5·04	500·09
A. Tomerini	Balingup ...	White Tail	HJ 24	Jersey ...	5·84	481·33
A. Miller	Cowaramup	Babs ...	KM 10	do. ...	5·20	462·13
W. Blair	Forest Grove	Betty ...	IL 14	Guernsey ...	4·90	460·51
Misses E. & I. Rutherford	Albany ...	Biddy ...	SD 4	Jersey x Ayrshire	4·19	441·56
T. B. Stanley ...	Benger ...	Polly ...	OM 9	Shorthorn ...	4·50	441·44
C. Gilmour	Dardanup	Seven ...	FE 7	Jersey ...	4·65	438·12
L. Westcott	Serpentine	Maggie ...	BG 15	Shorthorn x	4·85	434·62
H. G. Letchford (sen.)	Greenbushes	Pokey ...	QX 10	Jersey ...	4·90	433·75
S. Sansom	Ruabon ...	Lily ...	OK S 12	Shorthorn ...	4·03	410·38
W. Leo	Manjimup	Queenie...	ML 14	Guernsey x	4·20	403·90
Narrogin School of Agriculture	Narrogin ...	Cloud ...	YD 6	Ayrshire ...	4·68	375·57
F. Oliver	Northcliffe	Creamy ...	W⊣ 4	Guernsey ...	4·29	368·76
L. Johnston	Vasse ...	Daisy ...	LC 11	Jersey ...	5·84	334·24

The "Sunny-West" Cup presented by the South-West Co-operative Dairy Farmers, Ltd., to the owner of the four highest producing cows in any herd tested under the grade herd recording scheme has been won for the third year in succession by Mr. T. Jamieson, of Capel.

"Seven." Tattoo F.E.7. Highest producing cow in the Dardanup unit; 438 lbs. of butter fat in 9 months. Owned by Mr. C. Gilmour.

The records of Mr. Jamieson's four cows are as follows:—

	Lbs. Butter Fat.
Moana	688·95
Magpie	562·5
Felix	531·69
Betty 2nd	508·35
Average	572·87

The only cow in this group which was in the winning *four* last year was "Betty 2nd" which produced 541 lbs. butter fat during 1937-38.

The three leading cows were purchased by Mr. Jamieson amongst a number of stock which previously had been intended for the butcher but, owing to being near to calving, were passed into the dairy herd and proved to be the highest producing cows in that herd.

"Proved" Bulls.

Following the practice which was commenced in 1936-37, a further list of "proved" pure bred bulls having six or more daughters that have been tested and have produced over 200 lbs. butter fat has been compiled and is given below in Table 13.

During the previous two years the names of 90 bulls and the average production of their daughters, together with the names of the owners of these bulls where such are known, were published and the present list contains the names of a further 55 "proved" sires.

In view of the comparative scarcity of these "proved" bulls, it is hoped that all daughters of these sires, which are from cows testing over 250 lbs. butter fat and, therefore, are eligible for identification under the Calf Marking Scheme, will be marked and registered.

TABLE 13.

BULLS WITH SIX OR MORE DAUGHTERS WHICH HAVE PRODUCED NOT LESS THAN 200 LBS. BUTTER FAT.

Name of Sire.	No. Daughters Tested.	Butter Fat.	Owner's Name.	Unit.	
		Average lbs.			
Guernsey—					
Koojan Golden Dividend	13	386	G. Omedei ...	Pemberton	Dead
Rosendale Prince ...	7	323	Mrs. L. R. Barnsby	do.	
Wollongbar Mandate ...	8	273	do. do.	do.	Dead
Minnamurra Aladdin ...	8	236	J. Jay	Northcliffe	Killed
Woolumbin Eastern King	11	235	J. Downes ...	do.	do.
Woolumbin Pastor ...	6	255	J. Jay	do.	do.
Nundorah Cloud Sovereign	8	235	G. Jackson ...	do.	Dead
Australian Illawarra Shorthorn—					
Wooroloo Bobs ...	7	305	Late R. R. Graham	Pemberton	
Hill View First Hope ...	13	281	P. Fitzpatrick ...	Cookernup	
Tipperary Camelia's Re-Echo	23	255	W. Palmer ...	do.	
Glan Avon Percy ...	11	201	Mrs. L. Faulkner & Sons	Albany	
Telyarup Renown ...	14	231	J. J. Daly ...	do.	
Telyarup Major ...	11	212	A. W. Collins ...	Coolup	
Minathorpe Bruce 4th ...	28	237	Kingsley Fairbridge Farm	Pinjarra	
Gentle Signal of Sarnia	33	229	do. do.	do.	
Jersey—					
Grassvale Broken Duke	15	291	E. W. Dilkes ...	Catterick-Greenbushes	Dead
Moorland's Digger ...	17	295	H. Williams ...	do.	10 yrs.
Noble Fondant ...	16	297	F. Heywood ...	do.	Dead
Juadine Gay Lad ...	15	260	do. ...	do.	do.
Masterpiece of Landscape Hill	12	270	O. L. Myers ...	Forest Grove	
Melrose Spiriter ...	12	248	Now unknown ...	do.	
Maxon's Starbright Prince	9	321	do. ...	do.	
Sabina Vale Airio ...	13	279	A. & A. E. Millar	do.	
King's Vale Banner ...	7	304	Now unknown ...	do.	
Aghyl Dere Bonnie Prince	6	233	J. H. Oldfield ...	do.	
Capel's Noble	20	269	Now unknown ...	do.	
Eurach Red-cloud ...	20	273	W. J. Rowe ...	do.	
Nooka King Twilish ...	8	285	S. West	do.	
Mokine Jock	9	269	G. Davis	do.	
Grass Vale Fowler's Twilish	31	306	J. Salerian ...	Cookernup	
Melrose Sultan	6	290	G. Scott	Boyanup	
Mokine Hero	6	324	F. Richards ...	Dardanup	
Mokine Mystery ...	6	207	W. Atkins ...	do.	
Companile's Duke of Grass Vale	6	266	G. H. Brett ...	do.	
Noble Fowler of Grass Vale	10	322	E. M. Rose ...	Serpentine	
Grass Vale Twylish ...	6	246	do. ...	do.	
Mokine Apollo	23	220	A. Thorne ...	Rosa Brook	
Rosecliffe Noble Lord ...	6	286	R. Hayward ...	do.	
Roseworthy Majestic ...	7	281	J. A. Nilsson ...	do.	
Karrawarra Graceful Willie	16	227	do.	do.	Dead

TABLE 13—*continued.*

Name of Sire.	No. Daughters Tested.	Butter Fat.	Owner's Name.	Unit.
		Average lbs.		
Jersey—*continued.*				
Colmyn Winkle ...	7	247	J. M. Nelson ...	Vasse
Nairn Ellisford	6	216	W. Packard ...	do.
Garden Hill Sportsman	9	224	Gorton & Gumprich	Coolup
Moorland's Dago ...	20	260	O. F. H. Bowles ...	do.
Travalgan Air Chief ...	27	237	W. M. Smith ...	do.
Greenmount Gay Lord	11	270	J. Davidson ...	do.
Colmyn Prince George ...	8	250	D. Morris ...	Ruabon
Colmyn Rye Prince ...	6	251	L. Wetherley ...	do.
Ayrshire—				
Tipperary Moonlight ...	6	299	W. P. Harris ...	Dardanup
Creamery Prince ...	6	291	T. P. Harris ...	do.
Ferndale Blueboy ...	13	264	R. H. Briggs ...	Serpentine
Friesian—				
Chittering Patrick Korndyke	10	277	Geo. Betts ...	Serpentine
Dunmore Duncan ...	10	255	do.	do.
Dunmore Ivanhoe ...	18	316	W. Taylor ...	do.
Red Poll—				
Aberbechan George ...	6	246	C. Flynn	Dardanup

Average Production of all Units.

Particulars of the production of the herds in all Units which were under test during 1938-39 are appended hereunder.

Donnybrook "A."	No. of Cows.	Butter-fat Average.	Serpentine "B."	No. of Cows.	Butter-fat Average.
		lbs.			lbs.
O. Foan ("L")	19	336·81	L. Westcott ("G") ...	21	307·56
A. Clifford & Sons ("G*")	16	328·35	F. E. Jackman ("R")...	25	280·86
W. J. Sears ("A") ...	25	307·49	G. Scott ("U") ...	15	270·42
Herd F*	16	301·26	Herd H	19	267·21
,, C	14	285·28	,, V	25	245·20
,, RA	9	272·19	,, O	28	242·11
,, RD	14	267·03	,, T	20	238·97
,, H	25	265·11	,, M	15	237·88
,, L*	18	247·18	,, A	65	235·72
,, P*	8	244·97	,, S	26	220·51
,, F	32	235·14	,, L	8	218·41
,, RX	27	231·26	,, N	11	208·32
,, E	21	229·99	,, X	13	206·25
,, C	10	227·60	,, E	15	202·26
,, RJ*	11	226·63	,, C	13	190·47
,, E	44	221·03	,, D	16	137·24
,, X	31	220·23			
,, C*	21	217·48			
,, D	39	216·51			
,, —A	27	214·23			
,, RK	11	209·16			
,, —B	40	205·11			
,, RY	11	199·06			
,, RF*	34	194·93			
,, A*	26	183·86			
,, RP	12	183·19			
,, K	30	182·10			
,, RR	12	178·66			
,, RJ	21	170·32			

* Letter reversed.

Cookernup "C."	No. of Cows.	Butter-fat Average.
		lbs.
T. Twaddle ("J*") ...	17	328·52
J. McEwin ("Y") ...	13	311·07
L. C. Winduss ("B") ...	30	299·10
Herd CS	78	289·55
„ 9C	69	280·38
„ R*	11	279·71
„ L	30	273·24
„ 6C	36	270·66
„ E*	25	269·76
„ P	22	259·82
„ 4C	35	252·64
„ A	9	252·16
„ J	23	248·24
„ Y*	64	245·21
„ 7C	78	242·72
„ F*	28	219·97
„ T	26	218·56
„ 2C	16	216·57
„ F	69	215·88
„ D	30	213·58
„ V	41	170·48

Harvey "D."	No. of Cows.	Butter-fat Average.
		lbs.
L. Temple ("C") ...	13	345·12
Mrs. A. G. Eckersley ("E")	23	284·10
E. Holthouse ("AC") ...	18	278·62
Herd AN	15	274·35
„ A	35	273·09
„ T	33	268·55
„ NM	16	267·59
„ ND	22	264·90
„ P	32	259·23
„ B	25	255·07
„ NB	15	249·53
„ B*	43	241·59
„ NH	24	233·22
„ U	21	228·76
„ L†	28	221·17
„ AD	26	208·84
„ G	39	204·68
„ NR	27	204·22
„ AG	14	203·40
„ C*†	20	183·64

* Letter reversed. † Tested 7 months only.

Brunswick "E."	No. of Cows.	Butter-fat Average.
		lbs.
S. Bowers ("F")	31	351·10
A. F. Clifton & Co. ("Q")	26	326·66
R. Hutchinson ("R*") ...	25	323·29
Herd C*	38	321·84
„ M*	29	317·79
„ B*	50	317·75
„ B	34	311·95
„ T*	17	305·35
„ O	49	294·22
„ P*	23	289·35
„ A*	24	284·19
„ D	14	274·57
„ E	33	268·37
„ Q*	18	266·88
„ A	42	262·80
„ U	33	262·33
„ K*	50	256·77
„ X	37	255·20
„ H	25	254·06
„ L*	37	232·52
„ U*	39	210·18

Dardanup "F."	No. of Cows.	Butter-fat Average.
		lbs.
C. Gilmour ("E") ...	31	293·25
A. Wicksteed ("W") ...	14	269·80
F. Richards ("I") ...	15	269·29
Herd N	44	267·83
„ C	28	253·63
„ S	19	250·85
„ AE	18	249·56
„ A	39	241·09
„ A*Q	16	240·33
„ A*N...	22	235·65
„ A*E	60	234·52
„ A*L	66	232·65
„ D	69	219·44
„ A*D*	43	213·22
„ D*	26	211·16
„ M	28	204·90
„ A*M	37	203·28
„ C*	12	201·41
„ K	49	195·38
„ AI	51	193·11
„ A*K	32	186·45
„ A*M*	24	162·23
„ A*B*	22	161·56
„ A*C*	38	133·93

* Letter reversed.

Capel "G."	No. of Cows.	Butter-fat Average.
		lbs.
R. L. Maidment ("W")	11	362·50
C. P. House ("D") ...	30	337·80
T. Jamieson ("S") ...	52	294·85
Herd F	33	273·72
„ I	40	272·11
„ N	32	237·50
„ M	35	229·99
„ C	24	211·95
„ A	77	209·88
„ K	38	208·88
„ B	42	208·42
„ Z	65	207·71
„ O	13	201·47
„ P	9	177·24
„ J	39	176·61
„ U	28	172·97
„ R	40	169·08
„ V	71	161·90

Balingup "H."	No. of Cows.	Butter-fat Average.
		lbs.
A. Tomerini ("J") ...	34	352·15
S. C. Maidment ("S") ...	41	332·55
D. Scott ("K") ...	57	311·26
Herd N	29	306·57
„ A*	30	301·40
„ R	19	297·01
„ V	32	280·21
„ Z	35	276·38
„ U	38	269·90
„ Q	11	269·72
„ B*	26	264·71
„ D*	15	261·81
„ C	52	257·41
„ K*	42	254·44
„ F*	44	254·07
„ C*	28	247·66
„ Y	20	245·11
„ E	36	238·28
„ D	24	230·50
„ L	31	228·62
„ H4	20	217·84
„ P	29	217·70
„ HS	35	216·06
„ G*	45	204·94
„ J*	31	171·46

* Letter reversed.

Forest Grove "I."	No. of Cows.	Butter-fat Average.
		lbs.
H. Eddy ("U") ...	20	288·36
P. O'Farrell ("7") ...	19	281·17
T. Kitson ("V") ...	14	277·50
Herd F*	32	274·71
„ Z	21	265·43
„ D	42	255·02
„ L	20	253·47
„ C	17	246·50
„ T*	36	243·44
„ D*	17	238·37
„ P	16	237·37
„ T	17	237·29
„ K	17	231·66
„ Q	29	230·27
„ J*	26	228·60
„ B*	16	223·65
„ K*	19	214·57
„ E*	25	211·55
„ V*	20	202·40
„ G*	12	186·40
„ W	13	183·45
„ AB	4	124·87

Pemberton "J."	No. of Cows.	Butter-fat Average.
		lbs.
Mrs. L. R. Barnsby ("B")	19	327·49
G. B. Omodei ("O") ...	24	319·96
D. Della ("N") ...	13	305·10
Herd G	13	303·76
„ U	17	294·87
„ A	16	258·41
„ AB	10	251·97
„ C	13	251·54
„ Q	16	243·47
„ F	12	241·43
„ R	21	240·96
„ L	18	240·85
„ P	12	233·84
„ H	12	230·94
„ V	15	224·63
„ T	7	203·90
„ Y	14	185·87
„ X	7	185·57
„ Z	20	182·44
„ I	29	168·26

* Letter reversed.

Rosa Brook "K."	No. of Cows.	Butter-fat Average.
		lbs.
F. George ("Q") ...	16	305·04
W. Darnell ("U") ...	11	291·09
D. P. Smith ("E") ...	18	283·39
Herd T*	15	282·57
„ A*	17	275·05
„ A	34	272·36
„ Y*	21	269·92
„ Z	18	251·95
„ P	17	236·54
„ D	30	232·56
„ B*	30	227·17
„ W	19	225·14
„ S	18	218·89
„ R	14	217·97
„ E*	26	216·95
„ H	33	214·57
„ G*	28	212·80
„ B	25	208·38
„ J*	14	202·01
„ R*	32	199·15
„ C	25	197·38
„ X	24	186·57
„ F	29	182·80
„ G	26	157·04
„ D*	35	133·64

* Letter inverted.

Vasse "L."	No. of Cows.	Butter-fat Average.
		lbs.
D. H. Bell ("Z") ...	15	261·01
L. Johnston ("C") ...	27	247·42
R. J. Seymour ("P*")	24	227·29
Herd A*	14	201·38
„ H	23	189·32
„ T	37	183·70
„ V	13	182·49
„ D*	21	179·30
„ N*	40	175·92
„ K*	11	169·17
„ W	34	168·72
„ Y	24	168·19
„ J*	13	165·07
„ S*	26	161·03
„ M*	26	153·19
„ B*	23	139·54
„ G*	15	133·09
„ O	75	118·58

* Letter "lazy."

Manjimup "M."	No. of Cows.	Butter-fat Average.
		lbs.
W. Hamilton ("N") ...	13	273·27
W. J. Morgan ("I") ...	13	271·74
H. Brown ("Q") ...	17	270·58
Herd L	15	259·01
„ C	25	258·67
„ B	22	245·91
„ B*	19	245·66
„ A	53	233·71
„ D	18	229·45
„ E	23	226·24
„ V	11	218·88
„ J	12	210·25
„ Z	35	208·31
„ X	23	205·82
„ E*	26	197·51
„ F	27	197·05
„ K	17	195·97
„ T	18	195·64
„ U	19	191·28
„ S	31	189·65
„ C*	16	183·99
„ R	30	181·06
„ Y	47	180·00
„ G	26	172·45
„ W	25	141·49

* Letter reversed.

Benger "O."	No. of Cows.	Butter-fat Average.
		lbs.
J. Fimmel ("Y") ...	13	284·50
T. Stanley ("M") ...	43	279·10
W. Barnes ("G") ...	35	277·43
Herd E	59	276·79
„ J	35	270·21
„ D	20	254·38
„ F*	47	244·20
„ L	36	231·14
„ AA	14	228·38
„ C	15	223·30
„ Z	36	218·19
„ T	24	207·78
„ V	24	205·11
„ X	16	203·23
„ AE	12	202·56
„ B	31	201·22
„ AJ	21	187·75
„ S	18	182·38
„ P	42	177·63

* Letter inverted.

Pinjarra "P."	No. of Cows.	Butter-fat Average.
		lbs.
L. A. House ("L") ...	20	339·20
F. G. Williams ("M") ...	27	306·83
J. Davidson ("A*") ...	33	288·93
Herd J	26	279·56
„ B	28	265·82
„ U	22	260·51
„ B*	11	244·72
„ F	19	240·77
„ A	37	231·39
„ Y	43	226·52
„ AB	12	224·18
„ N	22	223·25
„ V	10	221·20
„ K	26	192·83
„ D	22	191·54
„ G	28	188·04
„ C	29	181·66
„ I	36	167·84
„ T	84	147·98
„ W	16	122·30

Greenbushes "Q."	No. of Cows.	Butter-fat Average.
		lbs.
H. G. Letchford, sen. ("X")	15	311·17
T. Giblett ("P*") ...	11	285·64
F. Capon ("V*") ...	20	274·92
Herd I	22	271·89
„ J	18	270·46
„ J*	15	264·19
„ H	30	263·69
„ V	28	256·74
„ P	26	248·06
„ Y*	15	247·26
„ B	20	244·27
„ C	42	228·45
„ L‖	19	215·35
„ Y	25	196·49
„ F	15	196·14
„ K	10	187·29
„ Z‡	61	186·09
„ K*‡	30	169·71
„ O‖	17	166·64
„ T*	22	159·90
„ A*‡	20	158·95
„ B§	21	156·77

* Letter reversed.

* Letter inverted. ‡ Tested 6 months only.

§ Tested 7 months only. ‖ Tested 8 months only.

Albany "S."	No. of Cows.	Butter-fat Average.
		lbs.
H. L. Newman ("B") ...	19	303·29
A Bracknell ("A*") ...	16	265·57
Misses Rutherford ("D")	5	262·05
Herd K*	16	255·84
„ L	23	244·46
„ Q*	18	224·85
„ F	10	219·51
„ J	15	218·07
„ I	20	217·99
„ X	22	216·14
„ Y	17	193·10
„ E	21	187·70
„ V*	28	186·05
„ R	14	180·91
„ G*	14	180·74
„ P*	35	179·12
„ B*	17	171·91
„ U*	20	169·55
„ A	27	163·03
„ C*	27	156·18
„ T	31	114·21

Bridgetown "T."	No. of Cows.	Butter-fat Average.
		lbs.
W. Watson ("C") ...	16	302·16
G. Henderson ("H") ...	22	285·78
G. H. Dixon ("K") ...	27	271·25
Herd A	45	247·16
„ Q	37	229·50
„ B	21	220·15
„ J	26	213·68
„ R	22	192·36
„ D	40	183·38
„ W	29	175·79
„ S	20	173·50
„ E	38	172·72
„ N	36	169·28
„ G	29	167·23
„ O	32	161·21
„ Z	16	160·18
„ F	24	158·79
„ L	59	151·29
„ V	16	149·01
„ U	46	129·16
„ M	38	128·39
„ P	18	102·62

* Letter reversed.

Metricup "U."	No. of Cows.	Butter-fat Average.
		lbs.
Messrs. Leiper and Dempster ("S")	62	333·20
J. Sibson ("T") ...	14	303·74
R. Cooper ("I") ...	13	297·88
Herd V	7	286·94
" B	24	267·69
" Q	32	266·18
" O	16	263·02
" H	21	254·56
" W	19	253·93
" L	24	252·80
" D	24	242·59
" P	23	234·43
" E	24	234·13
" N	35	232·34
" M	24	228·08
" G	18	224·09
" C	22	213·49
" J	24	212·91
" F	11	212·56
" A	22	190·56
" K	20	187·66
" R	11	176·80

Ruabon "V."	No. of Cows.	Butter-fat Average.
		lbs.
A. Teates ("W") ...	24	236·73
H. Billinghurst ("H") ...	30	236·00
S. Sansom ("P") ...	17	230·90
Herd N	35	228·55
" M	24	224·20
" K	30	220·01
" X	46	215·30
" O	28	214·17
" R	26	199·99
" D	9	197·90
" L	24	190·64
" S	39	187·35
" Y	17	177·17
" F	33	165·26
" Z	24	162·54
" E	23	156·83
" G	33	151·07
" A	24	149·02
" T	41	137·26
" B	37	134·67

Northcliffe "W."	No. of Cows.	Butter-fat Average.
		lbs.
G. Willis ("H") ...	19	247·85
H. Heathcote ("X") ...	19	231·19
J. Moran ("F") ...	23	219·27
Herd L	15	218·96
" J	26	215·18
" B	21	211·82
" C	28	207·57
" M	19	199·35
" K	25	190·75
" D	24	188·93
" I*§	15	186·73
" T	14	184·32
" Z	16	184·20
" O	18	182·98
" G	36	181·96
" U	46	181·80
" E	20	170·55
" P	24	165·04
" S	25	162·21
" R	20	159·26
" V¶	11	159·19
" Y‖	22	142·16
" A	40	123·29
" N‡	11	99·76
" I†	15	88·32

Cowaramup "X."	No. of Cows.	Butter-fat Average.
		lbs.
A. Miller ("KM") ...	24	332·17
W. J. Burt ("H") ...	18	321·60
W. Blaikie ("A") ...	25	315·44
Herd KL	20	284·32
" I	24	270·35
" N	13	252·71
" KI	20	250·29
" T	24	230·22
" B	21	220·81
" G	17	217·47
" F	31	216·68
" KJ	27	215·05
" D	30	192·20
" C	28	191·14
" L	31	180·38
" Y	33	173·71
" J	24	159·60
" X	18	159·29
" KY	14	149·14

* Letter "lazy."
† Tested 3 months only.
‡ Tested 5 months only.
§ Tested 6 months only.
‖ Tested 7 months only.
¶ Tested 9 months only.

Narrogin "Y."	No. of Cows.	Butter-fat Average.	Narrogin "Y"—*contd.*	No. of Cows.	Butter-fat Average.
		lbs.			lbs.
D. Bradford ("H") ...	15	248·15	Herd A	45	146·45
Narrogin School of Agriculture ("D") ...	13	229·79	„ B	88	146·18
E. Booth ("E") ...	17	225·75	„ G	14	142·85
Herd F	13	211·26	„ J	16	138·56
„ I	12	205·35	„ K	14	133·30
„ C	10	188·50	„ L	14	110·43
			„ M	11	103·68

Plant Hormones and their Practical Importance in Horticulture.

By H. L. PEARSE, Ph.D., A.R.C.S., D.I.C.

Technical Communication No. 12 of the Imperial Bureau of Horticulture and Plantation Crops, East Malling, Kent, England, 1939. Price 3s. 6d. stg.

A recent aid to the horticulturist is the discovery of plant hormones, or auxins, which have been found to promote root development on cuttings and may be used successfully to improve the results of the plant propagator in the nursery. Dr. Pearse has described the practical application of this discovery in this small book, which has been compiled especially for the practical horticulturist.

During the last decade, the importance of growth promoting substances within the plant has been amply demonstrated. These substances, known as plant hormones or auxins, are produced in one part of the plant, generally the developing terminal buds and young leaves, and move to other parts where they stimulate growth activities. Of the growth activities, root production in cuttings is of paramount importance to the nurseryman and horticulturist.

It is true that the great German scientist, Sachs, in 1865 postulated the existence of substances which governed the growth processes of plants, but for nearly 70 years their identity defied discovery and their mode of action remained obscure. In 1933, three of these substances were discovered and their chemical composition determined. They were called auxins or plant hormones, and are considered by many plant physiologists to be indispensable for the growth of plants.

Dr. Pearse has devoted his attention largely to the practical application of the scientific discoveries and theories with respect to auxins or plant hormones to horticultural problems. Perhaps vegetative propagation is one of the most important of horticultural practices and any process which will facilitate the rooting of cuttings will be welcomed by horticulturists.

Research has shown that appropriate use of auxins will increase root formation and shorten the time required for roots to form with species which are easy or only moderately difficult to root. With those difficult to root, however, a response is frequently not so readily obtained and success is dependent on the selection of the most suitable material—condition of the wood, health of parent plant, appropriate care of the cuttings, the use of accessory substances such as the vitamin thiamin, etc. It is evident that each plant must be studied individually in order to determine the most suitable technique and appropriate auxin treatment to obtain the best results. In this connection, Dr. Pearse has tabulated for the benefit of propagators the published experience with respect to about 350 species of plants.

Since the discovery of the three natural auxins a number of other substances have been added to the list of substances effective as plant hormones. Extensive investigation has shown that three compounds, which may be prepared in the laboratory and are available in pure crystalline form from chemical firms, may be mentioned as particularly effective in promoting root formation. These are—

(1) -naphthalene-acetic acid,

(2) indolyl-butyric acid,

(3) indolyl-acetic acid.

They may be used—

(1) as a dip in which the base of the cutting is immersed for a number of hours,

(2) as a dust applied to the base of the cutting,

(3) as a paste when dissolved in lanoline,

(4) as a solution with which the cuttings are watered.

Of these, the first method seems most effective in practice.

On account of their very great physiological activity, auxins must be used in great dilution—0.001 per cent. to 0.02 per cent.: higher concentrations may be very injurious.

A wealth of detail is given in Dr. Pearse's paper and the attention of the reader desiring further information is directed to over 200 references used in the preparation of the text.

—L. J. H. TEAKLE.

Agricultural Problems.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper

and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

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